

**Biographical
Dictionary of the History
of Technology**



EDITED BY LANCE DAY AND IAN McNEIL

BIOGRAPHICAL DICTIONARY OF THE HISTORY OF TECHNOLOGY

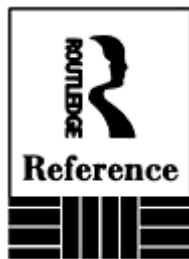
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OF TECHNOLOGY

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Edited by

Lance Day and Ian McNeil



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PREFACE

In 1990 Routledge published *An Encyclopaedia of the History of Technology*, edited by my good friend and fellow editor of the present work, Ian McNeil. The *Encyclopaedia* told the story of the inventiveness of human beings in applying their knowledge of the physical world to rendering their material circumstances less inconvenient and uncomfortable. Throughout the thousand and more pages of the *Encyclopaedia*, hundreds of characters flitted in and out, making tantalizingly brief appearances, before receding into the shadows. It is the aim of this biographical dictionary to bring these characters into the light of day, so we can see the background that produced them, the development of their inventions or discoveries and their significance in the area of technology concerned. We have selected almost 1,300 names of those whom we judge to have made a significant contribution, in one way or another, to the advance of technology.

The selection of these names was perhaps the most difficult part of the whole work. Technology has such wide ramifications, with vague boundaries with arts and crafts and, most difficult, with science. We have therefore encountered difficulties in selection which the compiler of a national biography, for example, does not have to cope with. We have tried not to duplicate the several biographical dictionaries of scientists, ranging from the handy works of reference to the magnificent series of volumes of the *Dictionary of Scientific Biography*. Nevertheless, many scientists have applied their discoveries to solving practical problems and thus also been 'technologists', or their discoveries have been so intimately bound up with a technological advance that it would seem too rigid to exclude them. Other names have been excluded for a variety of reasons. We would like to have included the inventors of the wheel, the smelting furnace or the glass blowing iron, but their names are lost in the mists of antiquity. At the other end of the time scale, it is not easy to identify discoverers, because many technical achievements this century have been by teams of workers at the behest of large companies. Sometimes a leading name can be identified; his or her co-worker will then be mentioned in the entry for the main contributor rather than duplicate much of the information in an entry for the co-worker. Indeed, many names of those who have made some contribution to a great advance but who do not rate an entry of their own are similarly 'mentioned in dispatches': they can all be traced by consulting the name index at the end of the book. Again, a number of inventors have achieved useful inventions, yet otherwise have left few traces. Sometimes we have decided that the importance of their contribution did not justify their inclusion; sometimes we felt the inventions were so useful that their authors merited an entry, however scrappy the information on them might be. The line we had to draw was often very fine.

We took as a starting point for the selection of names the name index to the *Encyclopaedia*, on the rude assumption that the authors of the chapters in that work would have mentioned any names worth mentioning. Some names, which had been given

merely a passing reference, such as Queen Victoria and King Solomon, were quickly deleted. We then divided the names into their respective subject areas and submitted them to whichever of our twenty six authors was expert in that subject. Here we should like to pay tribute to the technical and historical expertise and literary skill of the authors who have contributed to this work, as also to their patience, co-operation and determination. Their first task was to scan the list of names in their field and suggest additions or deletions. Their advice was much valued but we must make clear that the final responsibility for the content of this work is our own.

The content of these lists of names remained fluid until the end, for further names were thrown up by consulting the indexes of other works in technology, further reading and discussion, or even a chance news item on television or in the press, or out of the blue.

During the course of the work, we stepped back from the selection of names, to gain a general impression of it. It was clear that very nearly all the names fell, or fall—some living persons are included—within the category ‘male, white, European’ (including North American). There are, of course, rather sound historical reasons for what John Roberts has termed ‘the Triumph of the West’ in his recent book and television series. The scientific revolution of the seventeenth century was a European phenomenon, stemming from the intellectual developments of medieval Catholic Europe, with contributing influences from the Ancient and Oriental worlds. Again, the mass application of knowledge of the physical world in industrial-scale exploitation of natural and human resources, which we have come to call the ‘Industrial Revolution’, was likewise a European achievement. So it is unavoidable that this incredible concentration of technological activity should be reflected in the content of this work.

Nevertheless we have been keenly aware that skills and inventiveness are to be found in all cultures and all ages, and we have tried to incorporate those who are known by name to have made notable inventions or other technological advances. This has not been easy: we do not know who achieved that extraordinary piece of ironwork known as the Delhi Pillar, but we do know who in China has been credited with the invention of paper. We have received help and advice from a number of consultants in this and in other matters, recorded in the list of consultants and on the acknowledgements page, but it is perhaps right here to mention the outstanding help given by the Needham Research Institute, founded in Cambridge by the late Joseph Needham, without whom we could not have done anything like justice to the remarkable technological achievements of the Chinese.

Turning to a completely different culture, we noticed the efforts of the African-Americans: many inventors have struggled against crippling handicaps of rejection and poverty but few have had to contend with such adversity as the African-Americans of the last century, yet even while labouring under the yoke of slavery, they showed remarkable inventiveness and made useful contributions to humanity’s technological achievements. It is gratifying to be able to include here ‘the Real McCoy’.

Another aspect of the content has also been touched on: our consultants and our sources have suggested the names of many outstanding women scientists including a number of Nobel Prize winners. But we came to the conclusion that nearly all of them belonged rightly to the dictionaries of scientists, where many of their names are to be found, rather than the present work. Our attention has also been drawn to the recent book

by Autumn Stanley, *Mothers and Daughters of Invention*, which surveys women's contribution to technology. Here, although we found much of interest, we did not feel that many reached the tip of the great iceberg of the world's inventive achievements, which is all we have had the space to describe in this volume.

Finally we, together with the contributing authors, would like to acknowledge gratefully the help that has been given to us by many people and institutions. Individuals who have helped with particular entries are recorded on a separate page. Here we should like to express our gratitude to those who have helped in a general way. First we thank the publishers Routledge for launching this project and seeing it through with enthusiastic support, especially Mark Barragry, Senior Academic Reference Editor, Alex Clark and Colville Wemyss, Development Editors, and Kerry Munro, Copy Editor. Then, many libraries have been consulted but above all this country's principal, national library for the history of science and technology, the Science Museum Library, and we thank Ian Carter, Readers Services Librarian, and all his colleagues who have unfailingly rendered efficient and friendly help. Lastly, we thank our wives (one each), Mary and Cis, without whose forbearance and encouragement we might have started the course but would hardly have stayed it to the end.

LRD

November 1995

Publishers note: We are sorry to announce that Ian McNeil died in December 1997.

ACKNOWLEDGEMENTS

The Editors would like to express their thanks to the following people and organizations for their help in the preparation of this book; names of those whose help is acknowledged are given below in alphabetical order, followed by a note of the entries with which they helped and, in parentheses, the initials of the authors of those entries.

Sadao Aoki, Seimelkai Foundation: *Inoue Masaru* (PJGR)

John Bagley: *entries relating to aeronautics* (JDS)

F.Boyle, Royal Society of Chemistry Library: *Crawford, John William Croom* (LRD)

Judit Brody: *women technologists*

Dr J.A.Brongers: *Vermuyden, Sir Cornelius* (KM/LRD)

Denise Carter, ICI Chemicals & Polymers Library: *Gibson, R.O.* (LRD)

Dave Fairhurst: *England, George* (PJGR)

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Christine Heap, National Railway Museum: *Chapelon, André; England, George; Forrester, George; Stephenson, Robert* (PJGR)

The late Professor Alexander Kholodilin, University of Ocean Technology, St Petersburg: *Krylov, Alexei Nicolaevitch; Peter the Great; Popoff, Andrei Alexandrovitch; Yourkevitch, Vladimir Ivanovitch* (FMW)

Professor James Lovelock: *Lovelock, James Ephraim* (LRD)

Mr Philip Monro, Hampshire Advisory Technical Services Ltd: *Monro, Philip Peter* (LRD)

Dr Alex Moulton: *Moulton, Alexander* (IMcN)

The Needham Research Institute, Cambridge, and the late Dr Joseph Needham: *entries relating to the Chinese* (LRD)

The Printing History Library, St Bride's, London: *several entries relating to printing technology* (LRD)

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HOW TO USE THE DICTIONARY

In using this dictionary, the following notes will be useful. Cross reference entries are made from alternative forms of a name. If there is no entry for a desired name, the name index should be consulted, to direct the reader to the entry or entries where that name is mentioned. There is also an index to subjects and an index of inventions and discoveries, referring the reader to entries where these matters are mentioned.

Each entry has the same structure: after the name of the individual, his or her dates and places of birth and death are given, so far as these can be ascertained. Then follows the subject's nationality and a brief statement of his or her principal achievements. The nationality is normally that of the present description of the country of origin: thus Nikola Tesla is not given as 'Austrian' or 'Yugoslavian' but as 'Serbian'. Citizens of the United States of America are given as 'American'. British subjects are generally referred to as English, Scottish or Welsh, unless it is difficult to assign one of these to an individual. For emigrants, the countries of origin and adoption are normally given, as for example 'German/American'.

Then follows a brief biography of the subject, the main part of the entry. The aim is to sketch the subject's background and to describe his or her significance in the history of technology: how he or she came to make his or her discovery or invention and what its consequences were. For scientists, the emphasis is on their technological contributions rather than their scientific discoveries. Names printed in bold type in the text indicate other entries where relevant information can be found.

At the end of the entry, we give principal honours and distinctions, bibliography, that is, the subject's principal writings and publications (in chronological order), and 'further reading', giving a select few references to literature where further information can be found (in order of importance). The entry concludes with the initials of the author, whose identity can be traced by consulting the list of contributors which precedes the editors' preface.

A

Abel, Sir Frederick August

b. 17 July 1827 Woolwich, London, England

d. 6 September 1902 Westminster, London, England

English chemist, co-inventor of cordite and explosives expert.

His family came from Germany and he was the son of a music master. He first became interested in science at the age of 14, when visiting his mineralogist uncle in Hamburg, and studied chemistry at the Royal Polytechnic Institution in London. In 1845 he became one of the twenty-six founding students, under A.W.von **Hofmann**, of the Royal College of Chemistry. Such was his aptitude for the subject that within two years he became von Hermann's assistant and demonstrator. In 1851 Abel was appointed Lecturer in Chemistry, succeeding Michael Faraday, at the Royal Military Academy, Woolwich, and it was while there that he wrote his *Handbook of Chemistry*, which was co-authored by his assistant, Charles Bloxam.

Abel's four years at the Royal Military Academy served to foster his interest in explosives, but it was during his thirty-four years, beginning in 1854, as Ordnance Chemist at the Royal Arsenal and at Woolwich that he consolidated and developed his reputation as one of the international leaders in his field. In 1860 he was elected a Fellow of the Royal Society, but it was his studies during the 1870s into the chemical changes that occur during explosions, and which were the subject of numerous papers, that formed the backbone of his work. It was he who established the means of storing gun-cotton without the danger of spontaneous explosion, but he also developed devices (the Abel Open Test and Close Test) for measuring the flashpoint of petroleum. He also became interested in metal alloys, carrying out much useful work on their composition. A further avenue of research occurred in 1881 when he was appointed a member of the Royal Commission set up to investigate safety in mines after the explosion that year in the Sealham Colliery. His resultant study on dangerous dusts did much to further understanding on the use of explosives underground and to improve the safety record of

the coal-mining industry. The achievement for which he is most remembered, however, came in 1889, when, in conjunction with Sir James **Dewar**, he invented cordite. This stable explosive, made of wood fibre, nitric acid and glycerine, had the vital advantage of being a ‘smokeless powder’, which meant that, unlike the traditional ammunition propellant, gunpowder (‘black powder’), the firer’s position was not given away when the weapon was discharged. Although much of the preliminary work had been done by the Frenchman Paul Vieille, it was Abel who perfected it, with the result that cordite quickly became the British Army’s standard explosive.

Abel married, and was widowed, twice. He had no children, but died heaped in both scientific honours and those from a grateful country.

Principal Honours and Distinctions

Grand Commander of the Royal Victorian Order 1901. Knight Commander of the Most Honourable Order of the Bath 1891 (Commander 1877). Knighted 1883. Created Baronet 1893. FRS 1860. President, Chemical Society 1875–7. President, Institute of Chemistry 1881–2. President, Institute of Electrical Engineers 1883. President, Iron and Steel Institute 1891. Chairman, Society of Arts 1883–4. Telford Medal 1878, Royal Society Royal Medal 1887, Albert Medal (Society of Arts) 1891, Bessemer Gold Medal 1897. Hon. DCL (Oxon.) 1883, Hon. DSc (Cantab.) 1888.

Bibliography

1854, with C.L.Bloxam, *Handbook of Chemistry: Theoretical, Practical and Technical*, London: John Churchill; 2nd edn 1858.

Besides writing numerous scientific papers, he also contributed several articles to *The Encyclopaedia Britannica*, 1875–89, 9th edn.

Further Reading

Dictionary of National Biography, 1912, Vol. 1, Suppl. 2, London: Smith, Elder.

CM

Abel, John Jacob

b. 19 May 1857 near Cleveland, Ohio, USA

d. 26 May 1938 Baltimore, Maryland, USA

*American pharmacologist and physiologist, proponent of the 'artificial kidney'
and the isolator of pure insulin.*

Born of German immigrant farming stock, his early scientific education at the University of Michigan, where he graduated PhB in 1883, suffered from a financially dictated interregnum of three years. In 1884 he moved to Leipzig and worked under **Ludwig**, moving to Strasbourg where he obtained his MD in 1888. In 1891 he was able to return to the University of Michigan as Lecturer in Materia Medica and Therapeutics, and in 1893 he was offered the first Chair of Pharmacology at Johns Hopkins University, a position he occupied until 1932. He was a pioneer in emphasizing the importance of chemistry, in its widest sense, in medicine and physiology. In his view, 'the investigator must associate himself with those who have laboured in fields where molecules and atoms rather than multi-cellular tissues or even unicellular organisms are the units of study'.

Soon after coming to Baltimore he commenced work on extracts from the adrenal medulla and in 1899 published his work on epinephrine. In later years he developed an 'artificial kidney' which could be used to remove diffusible substances from the blood. In 1913 he was able to demonstrate the existence of free amino-acids in the blood and his investigations in this field foreshadowed not only the developments of blood and plasma transfusion but also the possibility of the management of renal failure.

From 1917 to 1924 he moved to a study of the hormone content of pituitary extracts, but in 1924 he suddenly transferred his attention to the study of insulin. In 1925 he announced the discovery of pure crystalline hormone. This work at first failed to gain full acceptance, but as late as 1955 the full elucidation of the protein structure of insulin proved the final culmination of his studies.

Abel's dedication to laboratory research and his disdain for matters of administration may explain the relative paucity of worldly honours awarded to such an outstanding figure.

Principal Honours and Distinctions

FRS.

Bibliography

1913, 'On the removal of diffusible substances from the circulating blood by means of dialysis', *Transactions of the Association of American Physiologists*.

Further Reading

1939, *Obituary Notices, Fellows of the Royal Society*, London: Royal Society.

1946, *Biographical Memoir: John Jacob Abel. 1857–1938*, Washington, DC: National

Abney, William de Wiveleslie

b. 24 July 1843 England

d. 2 December 1920 England

English photographic scientist, inventor and author.

Abney began his career as an officer in the Army and was an instructor in chemistry in the Royal Engineers at Chatham, where he made substantial use of photography as a working tool. He retired from the Army in 1877 and joined the Science and Art Department at South Kensington. It was at Abney's suggestion that a collection of photographic equipment and processes was established in the South Kensington Museum (later to become the Science Museum Photography Collection).

Abney undertook significant researches into the nature of gelatine silver halide emulsions at a time when they were being widely adopted by photographers. Perhaps his most important practical innovations were the introduction of hydroquinone as a developing agent in 1880 and silver gelatine citrochloride emulsions for printing-out paper (POP) in 1882. However, Abney was at the forefront of many aspects of photographic research during a period of great innovation and change in photography. He devised new techniques of photomechanical printing and conducted significant researches in the fields of photochemistry and spectral analysis. Abney published throughout his career for both the specialist scientist and the more general photographic practitioner.

Principal Honours and Distinctions

KCB 1900. FRS 1877. Served at different times as President of the Royal Astronomical, Royal Photographic and Physical Societies. Chairman, Royal Society of Arts.

Further Reading

Obituary, 1921, *Proceedings of the Royal Society* (Series A) 99.

J.M.Eder, 1945, *History of Photography*, trans. E.Epstein, New York.

Abt, Roman

b. 17 July 1850 Bünzen, Switzerland
 d. 1 May 1933 Lucerne, Switzerland

Swiss locomotive engineer, inventor of the Abt rack rail system.

Abt trained under **N. Riggenbach** and worked for his short-lived International Company for Mountain Railways during the 1870s, and subsequently invented the Abt rack system as an improvement on Riggenbach's ladder rack, in which the rungs gave trouble by working loose. Abt's rack system, in what became its usual form, comprises two machined racks side by side with their teeth staggered so that a tooth in one rack is opposite a recess in the other, and at least one tooth is always engaged with a locomotive's driving pinions. This system was first used in 1884 on the mixed rack-and-adhesion Harz Railway in Germany, and then largely superseded Riggenbach's system for new rack railways built worldwide to an eventual total of seventy-two, including the Snowdon Mountain Railway in the UK that was built in the 1890s. In many cases Abt himself designed locomotives and rolling stock, and supervised their construction.

Bibliography

1877–8, Abstract in *Minutes of Proceedings of the Institution of Civil Engineers*, Vol. 52 (part II) (abstract of a paper given by Abt in which he described eight Riggenbach system railways then operating; his own system was patented in 1882).

Further Reading

J.Marshall, 1978, *A Biographical Dictionary of Railway Engineers*, Newton Abbot: David & Charles.

O.J.Morris, 1951, *Snowdon Mountain Railway*, Ian Allan.

PJGR

Achard, Franz

b. 1753 Germany
 d. 1821 Germany

German scientist of French descent who built the world's first factory to extract sugar from beet.

The descendant of a French refugee, Achard began the systematic study of beet on his estate at Caulsdorf in 1786. The work had been stimulated by the discovery in 1747 of the presence of sugar in fodder beet. This research had been carried out by Andreas Marggraf, under whom Franz Achard trained. After a fire destroyed his laboratories Achard established himself on the domain of Französisch in Buchholtz near Berlin.

After thirteen years of study he felt sufficiently confident to apply for an interview with Frederick William III, King of Prussia, which took place on 11 January 1799. Achard presented the King with a loaf of sugar made from raw beet by his Sugar Boiling House method. He requested a ten-year monopoly on his idea, as well as the grant of land on which to carry out his work. The King was sufficiently impressed to establish a committee to supervise further trials, and asked Achard to make a public statement on his work. The King ordered a factory to be built at his own expense, and paid Achard a salary to manage it. In 1801 he was granted the domain of Cunern in Silesia; he built his first sugar factory there and began production in 1802. Unfortunately Achard's business skills were negligible, and he was bankrupt within the year. In 1810 the State relieved him of his debt and gave him a pension, and in 1812 the first sugar factory was turned into a school of sugar technology.

Bibliography

Achard's public response to the King's request was his paper *Abhandlungen über die Kultur der Runkelrube*.

Further Reading

Noel Deerr, 1950, *The History of Sugar*, Vol. II, London (deals with the development of sugar extraction from beet, and therefore the story of both Marggraf and Achard).

AP

Ackermann, Rudolph

b. 20 April 1764 Stolberg, Saxony

d. 30 March 1834 Finchley, London, England

German-born fine-art publisher and bookseller, noted for his arrangement of the steering of the front wheels of horse-drawn carriages, which is still used in automobiles today.

Ackermann's father was a coachbuilder and harness-maker who in 1775 moved to Schneeberg. Rudolph was educated there and later entered his father's workshop for a short time. He visited Dresden, among other towns in Germany, and was resident in Paris for a short time, but eventually settled in London. For the first ten years of his life there he was employed in making designs for many of the leading coach builders. His steering-gear consisted of an arrangement of the track arms on the stub axles and their connection by the track rod in such a way that the inner wheel moved through a greater angle than the outer one, so giving approximately true rolling of the wheels in cornering. A necessary condition for this is that, in the plan view, the point of intersection of the axes of all the wheels must be at a point which always lies on the projection of the rear axle. In addition, the front wheels are inclined to bring the line of contact of the front wheels under the line of the pivots, about which they turn when cornering. This mechanism was not entirely new, having been proposed for windmill carriages in 1714 by Du Quet, but it was brought into prominence by Ackermann and so has come to bear his name.

In 1801 he patented a method of rendering paper, cloth and other materials waterproof and set up a factory in Chelsea for that purpose. He was one of the first private persons to light his business premises with gas. He also devoted some time to a patent for movable carriage axles between 1818 and 1820. In 1805 he was put in charge of the preparation of the funeral car for Lord Nelson.

Most of his life and endeavours were devoted to fine-art printing and publishing. He was responsible for the introduction into England of lithography as a fine art: it had first been introduced as a mechanical process in 1801, but was mainly used for copying until Ackermann took it up in 1817, setting up a press and engaging the services of a number of prominent artists, including W.H.Pyne, W.Combe, Pugin and Thomas Rowlandson. In 1819 he published an English translation of J.A.Senefelder's *A Complete Course of Lithography*, illustrated with lithographic plates from his press. He was much involved in charitable works for widows, children and wounded soldiers after the war of 1814. In 1830 he suffered 'an attack of paralysis' which left him unable to continue in business. He died four years later and was buried at St Clement Danes.

Bibliography

His fine-art publications are numerous and well known, and include the following:

The Microcosm of London

University of Oxford

University of Cambridge

The Thames

The Rhine

English Lakes

Further Reading

Aubrey F.Burstall, 'A history of mechanical engineering', *Dictionary of National Biography*.

Acres, Birt

b. 23 July 1854 Virginia, USA

d. 1918

American photographer, inventor and pioneer cinematographer.

Born of English parents and educated in Paris, Acres travelled to England in the 1880s. He worked for the photographic manufacturing firm Elliott & Co. in Barnet, near London, and became the Manager. He became well known through his frequent lectures, demonstrations and articles in the photographic press. The appearance of the Edison kinoscope in 1893 seems to have aroused his interest in the recording and reproduction of movement.

At the beginning of 1895 he took his idea for a camera to Robert **Paul**, an instrument maker, and they collaborated on the building of a working camera, which Acres used to record the Oxford and Cambridge Boat Race on 30 March 1895. He filmed the Derby at Epsom on 29 May and the opening of the Kiel Canal in June, as well as ten other subjects for the kinoscope, which were sold by Paul. Acres's association with Paul ended in July 1895. Acres had patented the camera design, the Kinetic Lantern, on 27 May 1895 and then went on to design a projector with which he gave the first successful presentation of projected motion pictures to take place in Britain, at the Royal Photographic Society's meeting on 14 January 1896. At the end of the month Acres formed his own business, the Northern Photographic Company, to supply film stock, process and print exposed film, and to make finished film productions.

His first shows to the public, using the renamed Kineopticon projector, started in Piccadilly Circus on 21 March 1896. He later toured the country with his show. He was honoured with a Royal Command Performance at Marlborough House on 21 July 1896 before members of the royal family. Although he made a number of films for his own use, they and his equipment were used only for his own demonstrations. His last contribution to cinematography was the design and patenting in 1898 of the first low-cost system for amateur use, the Birtac, which was first shown on 25 January 1899 and marketed in May of that year. It used half-width film, 17.5 mm wide, and the apparatus served as camera, printer and projector.

Principal Honours and Distinctions

Fellow of the Royal Photographic Society 1895.

Bibliography

27 May 1895 (the Kinetic Lantern).

9 June 1898 (the Birtac).

Further Reading

J.Barnes, 1976, *The Beginnings of the Cinema in England*, London.

B.Coe, 1980, *The History of Movie Photography*, London.

BC

Adam, Robert

b. 3 July 1728 Kirkcaldy, Scotland

d. 3 March 1792 London, England

Scottish architect, active mostly in England, who led the neo-classical movement between 1760 and 1790.

Robert Adam was a man of outstanding talent, immense energy dedicated to his profession, and of great originality, who utilized all sources of classical art from ancient Greece and Rome as well as from the Renaissance and Baroque eras in Italy. He was also a very practical exponent of neo-classicism and believed in using the latest techniques to produce fine craftsmanship.

Of particular interest to him was stucco, the material needed for elegant, finely crafted ceiling and wall designs. Stucco, though the Italian word for plaster, refers architecturally to a specific form of the material. Known as *Stucco duro* (hard plaster), its use and composition dates from the days of ancient Rome. Giovanni da Udine, a pupil of Raphael, having discovered some fine *stucco antico* in the ruins of the Palace of Titus in Rome, carried out extensive research during the Italian Renaissance in order to discover its precise composition; it was a mixture of powdered crystalline limestone (travertine), river sand, water and powdered white marble. The marble produced an exceptionally hard stucco when set, thereby differentiating it from plaster-work, and was a material fine enough to make delicate relief and statuary work possible.

In the 1770s Robert Adam's ceiling and wall designs were characterized by low-relief, delicate, classical forms. He and his brothers, who formed the firm of Adam Brothers, were interested in a stucco which would be especially fine grained and hard setting. A number of new products then appearing on the market were easier to handle than earlier ones. These included a stucco by Mr David Wark, patented in 1765, and another by a Swiss clergyman called Liardet in 1773; the Adam firm purchased both patents and obtained an Act of Parliament authorizing them to be the sole vendors and makers of this stucco, which they called 'Adam's new invented patent stucco'. More new versions appeared, among which was one by a Mr Johnson, who claimed it to be an improvement. The Adam Brothers, having paid a high price for their rights, took him to court. The case was decided in 1778 by Lord Mansfield, a fellow Scot and a patron (at Kenwood), who,

unsurprisingly, gave judgement in favour of the Adams.

Principal Honours and Distinctions

Member of the Society of Arts 1758. FRS 1761.

Architect to the King's Works 1761.

Bibliography

1764, *Ruins of the Palace of the Emperor Diocletian at Spalatro* .

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J.Rykwert and A.Rykwert, 1985, *The Brothers Adam* , Collins.

D.Yarwood, 1970, *Robert Adam* , Dent.

DY

Adams, William Bridges

b. 1797 Madeley, Staffordshire, England

d. 23 July 1872 Broadstairs, Kent, England

English inventory particularly of road and rail vehicles and their equipment.

Ill health forced Adams to live abroad when he was a young man and when he returned to England in the early 1830s he became a partner in his father's firm of coachbuilders. Coaches during that period were steered by a centrally pivoted front axle, which meant that the front wheels had to swing beneath the body and were therefore made smaller than the rear wheels. Adams considered this design defective and invented equirota coaches, built by his firm, in which the front and rear wheels were of equal diameter and the coach body was articulated midway along its length so that the front part pivoted. He also applied himself to improving vehicles for railways, which were developing rapidly then.

In 1843 he opened his own engineering works, Fairfield Works in north London (he was not related to his contemporary William Adams, who was appointed Locomotive Superintendent to the North London Railway in 1854). In 1847 he and James Samuel, Engineer to the Eastern Counties Railway, built for that line a small steam inspection car,

the Express, which was light enough to be lifted off the track. The following year Adams built a broad-gauge steam railcar, the Fairfield, for the Bristol & Exeter Railway at the insistence of the line's Engineer, C.H.Gregory: self-propelled and passenger-carrying, this was the first railcar. Adams developed the concept further into a light locomotive that could haul two or three separate carriages, and light locomotives built both by his own firm and by other noted builders came into vogue for a decade or more.

In 1847 Adams also built eight-wheeled coaches for the Eastern Counties Railway that were larger and more spacious than most others of the day: each in effect comprised two four-wheeled coaches articulated together, with wheels that were allowed limited side-play. He also realized the necessity for improvements to railway track, the weakest point of which was the joints between the rails, whose adjoining ends were normally held in common chairs. Adams invented the fishplated joint, first used by the Eastern Counties Railway in 1849 and subsequently used almost universally.

Adams was a prolific inventor. Most important of his later inventions was the radial axle, which was first applied to the leading and trailing wheels of a 2-4-2 tank engine, the *White Raven*, built in 1863; Adams's radial axle was the forerunner of all later radial axles. However, the sprung tyres with which *White Raven* was also fitted (an elastic steel hoop was interposed between wheel centre and tyre) were not perpetuated. His inventiveness was not restricted to engineering: in matters of dress, his adoption, perhaps invention, of the turn-down collar at a time when men conventionally wore standup collars had lasting effect.

Bibliography

Adams took out some thirty five British patents, including one for the fishplate in 1847.

He wrote copiously, as journalist and author: his most important book was *English Pleasure Carriages* (1837), a detailed description of coachbuilding, together with ideas for railway vehicles and track. The 1971 reprint (Bath: Adams & Dart) has a biographical introduction by Jack Simmons.

Further Reading

C.Hamilton Ellis, 1958, *Twenty Locomotive Men*, Shepperton: Ian Allan, Ch. 1.

See also **England, George** .

PJGR

Adamson, Daniel

b. 1818 Shildon, Co. Durham, England

d. January 1890 Didsbury, Manchester, England

English mechanical engineer, pioneer in the use of steel for boilers, which

enabled higher pressures to be introduced; pioneer in the use of triple- and quadruple-expansion mill engines.

Adamson was apprenticed between 1835 and 1841 to Timothy Hackworth, then Locomotive Superintendent on the Stockton & Darlington Railway. After this he was appointed Draughtsman, then Superintendent Engineer, at that railway's locomotive works until in 1847 he became Manager of Shildon Works. In 1850 he resigned and moved to act as General Manager of Heaton Foundry, Stockport. In the following year he commenced business on his own at Newton Moor Iron Works near Manchester, where he built up his business as an iron-founder and boilermaker. By 1872 this works had become too small and he moved to a 4 acre (1.6 hectare) site at Hyde Junction, Dukinfield. There he employed 600 men making steel boilers, heavy machinery including mill engines fitted with the American Wheelock valve gear, hydraulic plant and general millwrighting.

His success was based on his early recognition of the importance of using high-pressure steam and steel instead of wrought iron. In 1852 he patented his type of flanged seam for the firetubes of Lancashire boilers, which prevented these tubes cracking through expansion. In 1862 he patented the fabrication of boilers by drilling rivet holes instead of punching them and also by drilling the holes through two plates held together in their assembly positions. He had started to use steel for some boilers he made for railway locomotives in 1857, and in 1860, only four years after **Bessemer's** patent, he built six mill engine boilers from steel for Platt Bros, Oldham. He solved the problems of using this new material, and by his death had made *c.* 2,800 steel boilers with pressures up to 250 psi (17.6 kg/cm²).

He was a pioneer in the general introduction of steel and in 1863–4 was a partner in establishing the Yorkshire Iron and Steel Works at Penistone. This was the first works to depend entirely upon Bessemer steel for engineering purposes and was later sold at a large profit to Charles Cammell & Co., Sheffield. When he started this works, he also patented improvements both to the Bessemer converters and to the engines which provided their blast. In 1870 he helped to turn Lincolnshire into an important ironmaking area by erecting the North Lincolnshire Ironworks. He was also a shareholder in ironworks in South Wales and Cumberland.

He contributed to the development of the stationary steam engine, for as early as 1855 he built one to run with a pressure of 150 psi (10.5 kg/cm) that worked quite satisfactorily. He reheated the steam between the cylinders of compound engines and then in 1861–2 patented a triple-expansion engine, followed in 1873 by a quadruple-expansion one to further economize steam. In 1858 he developed improved machinery for testing tensile strength and compressive resistance of materials, and in the same year patents for hydraulic lifting jacks and riveting machines were obtained.

He was a founding member of the Iron and Steel Institute and became its President in 1888 when it visited Manchester. The previous year he had been President of the Institution of Civil Engineers when he was presented with the Bessemer Gold Medal. He was a constant contributor at the meetings of these associations as well as those of the Institution of Mechanical Engineers. He did not live to see the opening of one of his final achievements, the Manchester Ship Canal. He was the one man who, by his indomitable energy and skill at public speaking, roused the enthusiasm of the people in Manchester for this project and he made it a really practical proposition in the face of strong

opposition.

Principal Honours and Distinctions

President, Institution of Civil Engineers 1887.

President, Iron and Steel Institute 1888. Institution of Civil Engineers Bessemer Gold Medal 1887.

Further Reading

Obituary, *Engineer* 69:56.

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Obituary, *Proceedings of the Institution of Civil Engineers* 100:374–8.

H.W.Dickinson, 1938, *A Short History of the Steam Engine*, Cambridge University Press (provides an illustration of Adamson's flanged seam for boilers).

R.L.Hills, 1989, *Power from Steam. A History of the Stationary Steam Engine*, Cambridge University Press (covers the development of the triple-expansion engine).

RLH

Ader, Clément

b. 2 April 1841 Muret, France

d. 3 May 1925 Toulouse, France

French engineer who made a short 'hop' in a powered aeroplane in 1890.

Ader was a distinguished engineer and versatile inventor who was involved with electrical developments, including the telephone and air-cushion vehicles. In the field of aeronautics he became the centre of a long-lasting controversy: did he, or did he not, fly before the **Wright** brothers' flight of 1903?

In 1882 Ader started work on his first aeroplane, the *Eole* (god of the winds), which was bat-like in appearance and powered by a very well-designed lightweight steam engine developing about 15 kW (20 hp). On 9 October 1890 the *Eole* was ready, and with Ader as pilot it increased speed over a level surface and lifted off the ground. It was airborne for about 5 seconds and covered some 50 m (164 ft), reaching a height of 20 cm (8 in.). Whether such a short hop constituted a flight has caused much discussion and argument over the years. An even greater controversy followed Ader's claim in 1906 that his third aeroplane (*Avion III*) had made a flight of 300 m (328 yd) in 1897. He repeated this claim in his book written in 1907, and many historians accepted his account of the 'flight'. C.H.Gibbs-Smith, an eminent aviation historian, investigated the Ader controversy and in his book published in 1966 came to the conclusion that the *Avion III* did not fly at all. *Avion III* was donated to the Museum of the Conservatoire des Arts et

Métiers in Paris, and still survives. From 1906 onwards Ader concentrated his inventive efforts elsewhere, but he did mount a successful campaign to persuade the French War Ministry to create an air force.

Principal Honours and Distinctions

In 1990 the French Government accepted him as the 'Father of Aviation who gave wings to the world'.

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Further Reading

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C.Carlier, 1990, *L'Affaire Clément Ader: la vérité rétablie*, Paris;

Pierre Lissarrague, 1990, *Clément Ader: inventeur d'avions*, Toulouse.

JDS

Af Chapman, Frederik Henrik

See **Chapman, Frederik Henrik** af .

Agricola, Georgius (Georg Bauer)

b. 24 March 1494 Glauchau, Saxony

d. 21 November 1555 Chemnitz, Germany

German metallurgist, who wrote the book De Re Metallica under the latinized version of his name.

Agricola was a physician, scientist and metallurgist of note and it was this which led to the publication of *De Re Metallica*. He studied at Leipzig University and between 1518 and 1522 he was a school teacher in Zwickau. Eventually he settled as a physician in

Chemnitz. Later he continued his medical practice at Joachimstal in the Erzgebirge. This town was newly built to serve the mining community in what was at the time the most important ore-mining field in both Germany and Europe.

As a physician in the sixteenth century he would naturally have been concerned with the development of medicines, which would have led him to research the medical properties of ores and base metals. He studied the mineralogy of his area, and the mines, and the miners who were working there. He wrote several books in Latin on geology and mineralogy. His important work during that period was a glossary of mineralogical and mining terms in both Latin and German. It is, however, *De Re Metallica* for which he is best known. This large volume contains twelve books which deal with mining and metallurgy, including an account of glassmaking. Whilst one can understand the text of this book very easily, the quality of the illustrative woodcuts should not be neglected. These illustrations detail the mines, furnaces, forges and the plant associated with them, unfortunately the name of the artist is unknown. The importance of the work lies in the fact that it is an assemblage of information on all the methods and practices current at that time. The book was clearly intended as a textbook of mining and mineralogy and as such it would have been brought to England by German engineers when they were employed by the Mines Royal in the Keswick area in the late sixteenth century. In addition to his studies in preparation for *De Re Metallica*, Agricola was an ‘adventurer’ holding shares in the Gottesgab mine in the Erzgebirge.

Principal Honours and Distinctions

Bibliography

1556, *De Re Metallica*, Basel; 1912, trans. H. Hoover and L.H. Hoover, London.

KM

Albert, Prince Consort

b. 26 August 1819 The Rosenau, near Coburg, Germany

d. 14 December 1861 Windsor Castle, England

German/British polymath and Prince Consort to Queen Victoria.

Albert received a sound education in the arts and sciences, carefully designed to fit him for a role as consort to the future Queen Victoria. After their marriage in 1840, Albert threw himself into the task of establishing his position as, eventually, Prince Consort and uncrowned king of England. By his undoubted intellectual gifts, unrelenting hard work and moral rectitude, Albert moulded the British constitutional monarchy into the form it retains to this day. The purchase in 1845 of the Osborne estate in the Isle of Wight

provided not only the growing royal family with a comfortable retreat from London and public life, but Albert with full scope for his abilities as architect and planner. With Thomas **Cubitt**, the eminent engineer and contractor, Albert erected at Osborne one of the most remarkable buildings of the nineteenth century. He went on to design the house and estate at Balmoral in Scotland, another notable creation.

Albert applied his abilities as architect and planner in the promotion of such public works as the London sewer system and, in practical form, the design of cottages for workers, such as those in south London, as well as those on the royal estates. Albert's other main contribution to technology was as educationist in a broad sense. In 1847, he was elected Chancellor of Cambridge University. He was appalled at the low standards and narrow curriculum prevailing there and at Oxford. He was no mere figurehead, but took a close and active interest in the University's affairs. With his powerful influence behind them, the reforming fellows were able to force measures to raise standards and widen the curriculum to take account, in particular, of the rapid progress in the natural sciences. Albert was instrumental in ending the lethargy of centuries and laying the foundations of the modern British university system.

In 1847 the Prince became Secretary of the Royal Society of Arts. With Henry Cole, the noted administrator who shared Albert's concern for the arts, he promoted a series of exhibitions under the auspices of the Society. From these grew the idea of a great exhibition of the products of the decorative and industrial arts. It was Albert who decided that its scope should be international. As Chairman of the organizing committee, by sheer hard work he drove the project through to a triumphant conclusion. The success of the Exhibition earned it a handsome profit for which Albert had found a use even before it closed. The proceeds went towards the purchase of a site in South Kensington, for which he drew up a grand scheme for a complex of museums and colleges for the education of the people in the sciences and the arts. This largely came to fruition and South Kensington today is a fitting memorial to the Prince Consort's wisdom and concern for the public good.

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 R.R.James, 1983, *Albert, Prince Consort: A Biography*, London: Hamish Hamilton (the standard modern biography).
 L.R.Day, 1989, 'Resources for the study of the history of technology in the Science Museum Library', *IATUL Quarterly* 3:122–39 (provides a short account of the rise of South Kensington and its institutions).

LRD

Albert, Wilhelm August Julius

b. 24 January 1787 Hannover, Germany

d. 4 July 1846 Clausthal, Harz, Germany

German mining official, successful applier of wire cable.

After studying law at the University of Göttingen, Albert turned to the mining industry and in 1806 started his career in mining administration in the Harz district, where he became Chief Inspector of mines thirty years later. His influence on the organization of the mining industry was considerable and he contributed valuable ideas for the development of mining technology. For example, he initiated experiments with **Reichenbach's** water-column pump in Harz when it had been working successfully in the transportation of brine in Bavaria, and he encouraged **Dörell** to work on his miner's elevator.

The increasing depths of shafts in the Harz district brought problems with hoisting as the ropes became too heavy and tended to break. At the beginning of the nineteenth century, iron link chains replaced the hempen ropes which were expensive and wore out too quickly, especially in the wet conditions in the shafts. After he had experimented for six years using counterbalancing iron link chains, which broke too easily, in 1834 he conceived the idea of producing stranded cables from iron wires. Their breaking strength and flexibility depended greatly on the softness of the iron and the way of laying the strands. Albert produced the cable by attaching the wires to strings which he turned evenly; this method became known as 'Albert lay'. He was not the first to conceive the idea of metal cables: there exists evidence for such cables as far back as Pompeii; **Leonardo da Vinci** made sketches of cables made from brass wires; and in 1780 the French engineer Reignier applied iron cables for lightning conductors. The idea also developed in various other mining areas, but Albert cables were the first to gain rapidly direct common usage worldwide.

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C.Bartels, 1992, *Vom frühneuzeitlichen Montangewerbe zur Bergbauindustrie*, Bochum: Deutsches Bergbau-Museum (evaluates his achievements within the framework of technological development in the Harz mining industry).

Albone, Daniel

b. c.1860 Biggleswade, Bedfordshire, England

d. 1906 England

English engineer who developed and manufactured the first commercially successful lightweight tractor.

The son of a market gardener, Albone's interest lay in mechanics, and by 1880 he had established his own business as a cycle maker and repairer. His inventive mind led to a number of patents relating to bicycle design, but his commercial success was particularly assisted by his achievements in cycle racing. From this early start he diversified his business, designing and supplying, amongst other things, axle bearings for the Great Northern Railway, and also building motor cycles and several cars. It is possible that he began working on tractors as early as 1896. Certainly by 1902 he had built his first prototype, to the three-wheeled design that was to remain in later production models. Weighing only 30 cwt, yet capable of pulling two binders or a two-furrow plough, Albone's Ivel tractor was ahead of anything in its time, and its power-to-weight ratio was to be unrivalled for almost a decade. Albone's commercial success was not entirely due to the mechanical tractor's superiority, but owed a considerable amount to his ability as a showman and demonstrator. He held two working demonstrations a month in the village of Biggleswade in Bedfordshire, where the tractors were made. The tractor was named after the river Ivel, which flowed through the village. The Ivel tractor gained twenty-six gold and silver medals at agricultural shows between 1902 and 1906, and was a significant contributor to Britain's position as the world's largest exporter of tractors between 1904 and 1914. Albone tried other forms of his tractor to increase its sales. He built a fire engine, and also an armoured vehicle, but failed to impress the War Office with its potential.

Albone died at the age of 46. His tractor continued in production but remained essentially unimproved, and the company finally lost its sales to other designs, particularly those of American origin.

Further Reading

Detailed contemporary accounts of tractor development occur in the British periodical *Implement and Machinery Review*. Accounts of the Ivel appear in 'The Trials of Agricultural Motors', *Journal of the Royal Agricultural Society of England* (1910), pp. 179–99. A series of general histories by Michael Williams have been published by Blandfords, of which *Classic Farm Tractors* (1984) includes an entry on the Ivel.

AP

Alden, George I.

b. 22 April 1843 Templeton, Massachusetts, USA

d. 13 September 1926 Princeton, Massachusetts, USA

American mechanical engineer and professor of engineering.

From 1868 to 1896 George Alden was head of the steam and mechanical engineering departments at the Worcester Polytechnic Institute, Worcester, Massachusetts. He made a donation in 1910 to establish a hydraulic laboratory at the Institute, and later a further donation for an extension of the laboratory which was completed in 1925. He was Chairman of the Board of Norton (Abrasives) Company and made a significant contribution to the theory of grinding in his paper in 1914 to the American Society of Mechanical Engineers. He was a member of that society from 1880, the year of its foundation, and took an active part in its proceedings.

Principal Honours and Distinctions

Vice-President, American Society of Mechanical Engineers 1891–3.

Bibliography

1914, 'Operation of grinding wheels in machine grinding', *Transactions of the American Society of Mechanical Engineers* 36:451–60.

Further Reading

For a description of the Alden Hydraulic Laboratory, see *Mechanical Engineering*, June 1926: 634–5.

RTS

Alexanderson, Ernst Frederik Werner

b. 25 January 1878 Uppsala, Sweden

d. ? May 1975 Schenectady, New York, USA

Swedish-American electrical engineer and prolific radio and television inventor responsible for developing a high-frequency alternator for generating radio waves.

After education in Sweden at the High School and University of Lund and the Royal Institution of Technology in Stockholm, Alexanderson took a postgraduate course at the Berlin-Charlottenburg Engineering College. In 1901 he began work for the Swedish C & C Electric Company, joining the General Electric Company, Schenectady, New York, the following year. There, in 1906, together with **Fessenden**, he developed a series of high-power, high-frequency alternators, which had a dramatic effect on radio communications and resulted in the first real radio broadcast. His early interest in television led to working demonstrations in his own home in 1925 and at the General Electric laboratories in 1927, and to the first public demonstration of large-screen (7 ft (2.13 m) diagonal) projection TV in 1930. Another invention of significance was the ‘amplidyne’, a sensitive manufacturing-control system subsequently used during the Second World War for controlling anti-aircraft guns. He also contributed to developments in electric propulsion and radio aerials.

He retired from General Electric in 1948, but continued television research as a consultant for the Radio Corporation of America (RCA), filing his 321st patent in 1955.

Principal Honours and Distinctions

Institution of Radio Engineers Medal of Honour 1919. President, IERE 1921. Edison Medal 1944.

Bibliography

Publications relating to his work in the early days of radio include:

‘Magnetic properties of iron at frequencies up to 200,000 cycles’, *Transactions of the American Institute of Electrical Engineers* (1911) 30: 2,443.

‘Transatlantic radio communication’, *Transactions of the American Institute of Electrical Engineers* (1919) 38:1,269.

The amplidyne is described in E.Alexanderson, M.Edwards and K.Boura, 1940, ‘Dynamo-electric amplifier for power control’, *Transactions of the American Institution of Electrical Engineers* 59:937.

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KF

Alexandria, Ctesibius of

See **Ctesibius of Alexandria** .

Alexandria, Hero of

See **Hero of Alexandria** .

al-Jazari, Ibn al-Razzaz

fl. c.1200 Arabia

Arab mechanician who constructed a series of ingenious water clocks with automata.

Al-Jazari entered the service of the Artuqid Kings of Diyar Bakir c.1180. In 1206 the then King, Nasir al-Din, instructed him to write a book describing the things he had constructed, among which were six water clocks. The timekeeping mechanism of these clocks was not innovative and was derived from earlier Hellenistic examples. Unlike Chinese and Hellenistic water clocks, al-Jazari's clocks had no astronomical indications and were intended to display the time, in temporal or unequal hours, both audibly and visually in an arresting and entertaining manner. The timekeeping was controlled by the flow of water from a vessel which contained a float to operate the clock mechanism. An ingenious device was used to ensure that the flow of water was constant during the day and could be set to a different constant flow during the night, to allow for the variation in the length of the temporal hours. Al-Jazari's clocks have not survived, but models have been constructed from the description and illustrations in the manuscripts.

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Further Reading

D.R.Hill, 1979, *The Country Life International Dictionary of Clocks*, ed. Alan Smith, London, pp. 130, 135 (a very brief but more accessible account).
 —1981, *Arabic Water-Clocks*, Aleppo.

DV

Allen, Horatio

- b. 10 May 1802 Schenectady, New York, USA
- d. 1 January 1890 South Orange, New Jersey, USA

American engineer, pioneer of steam locomotives.

Allen was the Resident Engineer for construction of the Delaware & Hudson Canal and in 1828 was instructed by J.B. **Jervis** to visit England to purchase locomotives for the canal's rail extension. He drove the locomotive *Stourbridge Lion*, built by J.U. **Rastrick**, on its first trial on 9 August 1829, but weak track prevented its regular use.

Allen was present at the Rainhill Trials on the Liverpool & Manchester Railway in October 1829. So was E.L. Miller, one of the promoters of the South Carolina Canal & Rail Road Company, to which Allen was appointed Chief Engineer that autumn. Allen was influential in introducing locomotives to this railway, and the West Point Foundry built a locomotive for it to his design; it was the first locomotive built in the USA for sale. This locomotive, which bore some resemblance to *Novelty*, built for Rainhill by John Braithwaite and John **Ericsson**, was named *Best Friend of Charleston*. On Christmas Day 1830 it hauled the first scheduled steam train to run in America, carrying 141 passengers.

In 1832 the West Point Foundry built four double-ended, articulated 2-2-0+0-2-2 locomotives to Horatio Allen's design for the South Carolina railroad. From each end of a central firebox extended two boiler barrels side by side with common smokeboxes and chimneys; wheels were mounted on swivelling sub-frames, one at each end, beneath these boilers. Allen's principal object was to produce a powerful locomotive with a light axle loading.

Allen subsequently became a partner in Stillman, Allen & Co. of New York, builders of marine engines, and in 1843 was President of the Erie Railroad.

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J.Marshall, 1978, *A Biographical Dictionary of Railway Engineers*, Newton Abbot: David & Charles.

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J.H.White Jr, 1994, 'Old debts and new visions', in *Common Roots—Separate Branches*, London: Science Museum, 79–82.

PJGR

Allen, John F.

b. 1829 England

d. 2 October 1900 New York (?), USA

English inventor of the Allen valve used on his pioneering high-speed engines.

Allen was taken to the United States from England when he was 12 years old. He became an engineer on the *Curlaw*, a freight boat running between New York and Providence. A defect which caused the engine to race in rough weather led Allen to invent a new valve gear, but he found it could not be fitted to the **Corliss** engine. In 1856 he patented an improved form of valve and operating gear to reduce back-pressure in the cylinder, which was in fact the reverse of what happened in his later engines. In 1860 he repaired the engines of a New York felt-hat manufacturer, Henry Burr, and that winter he was introduced to Charles **Porter**. Porter realized the potential of Allen's valves for his idea of a high-speed engine, and the Porter-Allen engine became the pioneer of high-speed designs.

Porter persuaded Allen to patent his new valves and two patents were obtained in 1862. These valves could be driven positively and yet the travel of the inlet could be varied to give the maximum expansion at different cut-offs. Also, the valves allowed an exceptionally good flow of steam. While Porter went to England and tried to interest manufacturers there, Allen remained in America and continued work on the engine. Within a few years he invented an inclined watertube boiler, but he seemed incapable of furthering his inventions once they had been placed on the market. Although he mortgaged his own house in order to help finance the factory for building the steam engine, in the early 1870s he left Porter and built a workshop of his own at Mott Haven. There he invented important systems for riveting by pneumatic machines through both percussion and pressure which led into the production of air compressors and riveting machines.

Further Reading

Obituaries appeared in engineering journals at the time of his death.

Dictionary of American Biography, 1928, Vol. I, New York: C.Scribner's Sons.

C.T.Porter, 1908, *Engineering Reminiscences*, New York: J.Wiley & Sons, reprint 1985,

Bradley, Ill.: Lindsay Publications (provides details of Allen's valve design).

R.L.Hills, 1989, *Power from Steam. A History of the Stationary Steam Engine*,

Cambridge University Press (covers the development of the Porter-Allen engine).

RLH

Alleyne, Sir John Gay Newton

b. 8 September 1820 Barbados

d. 20 February 1912 Falmouth, Cornwall, England

English iron and steel manufacturer, inventor of the reversing rolling mill.

Alleyne was the heir to a baronetcy created in 1769, which he succeeded to on the death of his father in 1870. He was educated at Harrow and at Bonn University, and from 1843 to 1851 he was Warden at Dulwich College, to the founder of which the family claimed to be related.

Alleyne's business career began with a short spell in the sugar industry at Barbados, but he returned to England to enter Butterley Iron Works Company, where he remained for many years. He was at first concerned with the production of rolled-iron girders for floors, especially for fireproof flooring, and deck beams for iron ships. The demand for large sections exceeded the capacity of the small mills then in use at Butterley, so Alleyne introduced the welding of T-sections to form the required H-sections.

In 1861 Alleyne patented a mechanical traverser for moving ingots in front of and behind a rolling mill, enabling one person to manipulate large pieces. In 1870 he introduced his major innovation, the two-high reversing mill, which enabled the metal to be passed back and forth between the rolls until it assumed the required size and shape. The mill had two steam engines, which supplied the motion in opposite directions. These two inventions produced considerable economies in time and effort in handling the metal and enabled much heavier pieces to be processed.

During Alleyne's regime, the Butterley Company secured some notable contracts, such as the roof of St Paneras Station, London, in 1868, with the then-unparalleled span of 240 ft (73 m). The manufacture and erection of this awe-inspiring structure was a tribute to Alleyne's abilities. In 1872 he masterminded the design and construction of the large railway bridge over the Old Maas at Dordrecht, Holland. Alleyne also devised a method of determining small quantities of phosphorus in iron and steel by means of the spectroscope. In his spare time he was a skilled astronomical observer and metalworker

in his private workshop.

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LRD

Ampère, André-Marie

b. 22 Jan 1775 Lyon, France

d. 10 June 1836 Marseille, France

French physicist and mathematician who established laws and principles relating magnetism and electricity to each other.

Ampère was reputed to have mastered all the then-known mathematics by the age of 12. He became Professor of Physics and Chemistry at Bourg in 1801 and a professor of mathematics at the Ecole Polytechnique in Paris in 1809. Observing a demonstration in 1820 of Oersted's discovery that a magnetic needle was deflected when placed near a current-carrying wire, Ampère was inspired to investigate the subject of electricity, of which he had no previous experience. Within a week he had prepared the first of several important communications on his discoveries to the Academy of Sciences in Paris. Included was a new hypothesis formed on the basis of his experiments on the relation between electricity and magnetism. He investigated the forces exerted on each other by current-carrying conductors and the properties of a solenoid. His mathematical theory describing these phenomena provided the foundations for the development of electrodynamics and his classic work *Théorie mathématique des phénomènes électrodynamiques* was published in 1827.

The name 'ampere' was adopted to replace the name 'weber' as a unit of current after Helmholtz proposed such a change in 1881.

Principal Honours and Distinctions

FRS 1827

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GW

Anderson, John

b. 1726 Roseneath, Dumbartonshire, Scotland
d. 13 January 1796

Scottish natural philosopher.

Born in Roseneath manse, son of the minister, he was educated after his father's death by an aunt, a Mrs Turner, to whom he later paid back the cost, and was later an officer in the corps that was raised to resist the rebellion of 1745. He studied at Glasgow, where in 1756 he became Professor of Oriental Languages and, in 1760, Professor of Natural Philosophy; he is notable for allowing artisans to attend his lectures in their working clothes. He planned the fortifications set up to defend Greenock in 1759, and was sympathetic with the French Revolution. He invented a cannon in which the recoil was counteracted by the condensation of air in the carriage. After unsuccessfully trying to interest the Government in this gun, he went to Paris in 1791 and offered it to the National Convention. While there he invented a means of smuggling French newspapers into Germany by the use of small balloons. He lost in a lawsuit with the other professors. In 1786 he published *Institutes of Physics*, which ran to five editions in ten years, and in 1800 he wrote on Roman antiquities. Upon his death he left all his library and apparatus to an educational institute, which was named after him but has now become the University of Strathclyde, Glasgow.

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IMcN

Anschutz, Ottomar

b. 1846 Lissa, Prussia (now Leszno, Poland)

d. 1907

German photographer, chronophotographer and inventor.

The son of a commercial photographer, Anschutz entered the business in 1868 and developed an interest in the process of instantaneous photography. The process was very difficult with the contemporary wet-plate process, but with the introduction of the much faster dry plates in the late 1870s he was able to make progress. Anschutz designed a focal plane shutter capable of operating at speeds up to 1/1000 of a second in 1883, and patented his design in 1888. It involved a vertically moving fabric roller-blind that worked at a fixed tension but had a slit the width of which could be adjusted to alter the exposure time. This design was adopted by C.P. Goerz, who from 1890 manufactures a number of cameras that incorporated it.

Anschutz's action pictures of flying birds and animals attracted the attention of the Prussian authorities, and in 1886 the Chamber of Deputies authorized financial support for him to continue his work, which had started at the Hanover Military Institute in October 1885. Inspired by the work of Eadweard **Muybridge** in America, Anschutz had set up rows of cameras whose focal-plane shutters were released in sequence by electromagnets, taking twenty-four pictures in about three-quarters of a second. He made a large number of studies of the actions of people, animals and birds, and at the Krupp artillery range at Meppen, near Essen, he recorded shells in flight. His pictures were reproduced, and favourably commented upon, in scientific and photographic journals.

To bring the pictures to the public, in 1887 he created the Electro-Tachyscope. The sequence negatives were printed as 90 x 120 mm transparencies and fixed around the circumference of a large steel disc. This was rotated in front of a spirally wound Geissler tube, which produced a momentary brilliant flash of light when a high voltage from an induction coil was applied to it, triggered by contacts on the steel disc. The flash duration, about 1/1000 of a second, was so short that it 'froze' each picture as it passed the tube. The pictures succeeded each other at intervals of about 1/30 of a second, and the observer saw an apparently continuously lit moving picture. The Electro-Tachyscope was shown publicly in Berlin at the Kulturministerium from 19 to 21 March 1887; subsequently **Siemens & Halske** manufactured 100 machines, which were shown throughout Europe and America in the early 1890s. From 1891 his pictures were available for the home in

the form of the Tachyscope viewer, which used the principle of the zoetrope: sequence photographs were printed on long strips of thin card, perforated with narrow slots between the pictures. Placed around the circumference of a shallow cylinder and rotated, the pictures could be seen in life-like movement when viewed through the slots.

In November 1894 Anschütz displayed a projector using two picture discs with twelve images each, which through a form of Maltese cross movement were rotated intermittently and alternately while a rotating shutter allowed each picture to blend with the next so that no flicker occurred. The first public shows, given in Berlin, were on a screen 6×8 m (20×26 ft) in size. From 22 February 1895 they were shown regularly to audiences of 300 in a building on the Leipzigstrasse; they were the first projected motion pictures seen in Germany.

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BC

Anthelm, Ludwig

fl. 1897, Germany

German who used carbon tetrachloride as a dry-cleaning agent.

Until the mid-nineteenth century, washing with soap and water was the only way to clean clothes. Around 1850 a kind of turpentine, camphene, began to be used (see J.B. **Jolly-Bellin**), but this necessitated taking the garments apart and resewing together after they had been cleaned. When benzene was introduced in 1866 by Pullars of Perth, Scotland, garments no longer needed to be taken apart. In 1897 Ludwig Anthelm of Leipzig started to use carbon tetrachloride (tetrachloromethane); however this was found to corrode the equipment and was dangerous to breathe, and it was replaced in Britain with trichlorethylene in 1918.

Further Reading

I.McNeil (ed.), 1990, *An Encyclopaedia of the History of Technology*, London: Routledge, p. 854 (an account of the introduction of dry-cleaning).

RLH

Anthemios of Tralles

fl. sixth century AD Tralles, Lydia, Asia Minor

Greek architect, geometer, mathematician and physicist.

Tralles was a wealthy city in ancient Greece. Ruins of the city are situated on a plateau above the present-day Turkish city of Aydin, in Asia Minor, which is near to Ephesus. In 334 BC Tralles was used as a base by Alexander the Great and later it was occupied by the Romans. After the collapse of the western half of the Roman Empire in the fifth century AD Tralles remained a part of the Byzantine Empire until its destruction in 1282.

Anthemios was one of the great sons of Tralles and was probably educated in Alexandria. He is especially famed as architect (with Isidorus of Miletos) of the great Church of Santa Sophia in Istanbul. This vast building, later a Turkish mosque and now a museum, was built for the Emperor Justinian between 532 and 537 AD. It was an early and, certainly for many centuries, the largest example of pendentive construction to support a dome. This form, using the spherical triangles of the pendentives, enabled a circular-based dome to be supported safely upon piers that stood on a square plan below. It gradually replaced the earlier squinch type of structure, though both forms of design stem from Middle Eastern origins. At Santa Sophia the dome rises to 180ft (55m) above floor level and has a diameter of over 100ft (30m). Together with Isidorus, Anthemios also worked upon the Church of the Holy Apostles in Istanbul.

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Procopius, 1913, *De Aedificiis, On the Buildings Constructed by the Emperor Justinian*, Leipzig.

Richard Krautheimer, 1965, *Early Christian and Byzantine Architecture*, Penguin.

DY

Apollonius of Perga

b. c.240 BC Perga, Pamphylia, Greece

d. 190 BC

Greek mathematician, geometer and astronomer.

Ruins of the ancient Greek city of Perga lie near to the Turkish town of Murtana, just inland from Antalya on the southern coast of Asia Minor. Apollonius, while quite young, went to Alexandria to study under the successors to Euclid. He also worked in Ephesus and Pergamum. He later carried out original studies into the geometrical proportions of conic sections, producing his famous work *Conies* and naming the ellipse, the parabola and the hyperbola. *Conics*, which appeared soon after 200 BC, consisted of eight treatises and earned him the name ‘the great geometer’, given to him by his contemporaries. Seven of the eight treatises have survived, four in the original Greek and three in Arabic translation; a Latin translation was edited by Halley in 1710. Apollonius also published works on the cylindrical helix and theories of the epicycles and eccentrics, with reference to the motion of the planets.

Further Reading

G.J.Toomer, *Apollonius: Conies*, Berlin: Springer Verlag.

DY

Appert, Nicolas

b. 1749 Châlons-sur-Marne, France

d. 1841

French confectioner who invented canning as a method of food preservation.

As the son of an inn keeper, Nicolas Appert would have learned about pickling and brewing, but he chose to become a chef and confectioner, establishing himself in the rue des Lombards in Paris in 1780. He prospered there until about 1795, and in that year he began experimenting in ways to preserve foodstuffs, succeeding with soups, vegetables, juices, dairy products, jellies, jams and syrups. His method was to place food in glass jars, seal the jars with cork and sealing wax, then sterilize them by immersion in boiling water for a predetermined time.

In 1810 the French Government offered a 12,000 franc award to anyone succeeding in preserving high-quality foodstuffs for its army and navy. Appert won the award and in 1812 used the money to open the world’s first food-bottling factory, La Maison Appert, in the town of Massey, near Paris. He established agents in all the major sea ports, recognizing the marine market as his most likely customer, and supplied products to Napoleon’s troops in the field. By 1820 Appert’s method was in use all over the United States, in spite of the simultaneous development of other containers of tin or other metals by an English merchant, Peter **Durand**, and the production of canned food products by

the Bermondsey firm of Donkin & Hall, London. The latter had opened the first canning factory in England in 1811.

Initially Appert used glass jars and bottles, but in 1822 he changed to tin-plated metal cans. To heat the cans he used an autoclave, which heated the water to a temperature higher than its boiling point. A hammer and chisel were needed to open cans until the invention of a can opener by an Englishman named Yates in 1855. Despite Appert's successes, he received little financial reward and died in poverty; he was buried in a common grave.

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AP

Appleby, John F.

b. 1840 New York, US A

d. ? USA

American inventor of the knotting mechanism used on early binders and still found on modern baling machines.

As a young man John Appleby worked as a labourer for a farmer near Whitewater in Wisconsin. He was 18 when the farmer bought a new reaping machine. Appleby believed that the concept had not been progressed far enough and that the machine should be able to bind sheaths as well as to cut the corn. It is claimed that while watching a dog playing with a skipping rope he noticed a particular knot created as the dog removed its head from the loop that had passed over it, and recognized the potential of the way in which this knot had been formed. From a piece of apple wood he carved a device that would produce the knot he had seen. A local school teacher backed Appleby's idea with a \$50 loan, but the American Civil War and service in the Union Army prevented any further development until 1869 when he took out a patent on a wire-tying binder. A number of the devices were made for him by a company in Beloit. Trials of wire binders held in

1873 highlighted the danger of small pieces of wire caught up in the hay leading to livestock losses. Appleby looked again at the possibility of twine. In 1875 he successfully operated a machine and the following season four were in operation. A number of other developments, not least Behel's 'bill hook' knotting device, were also to have an influence in the final development of Appleby's twine-tying binder. As so often happens, it was the vision of the entrepreneur which ultimately led to the success of Appleby's device. In 1877 Appleby persuaded William **Deering** to produce and market his binder, and 3,000 twine binders, together with the twine produced for them, were put on the market in 1880, with immediate success. Over the next dozen years all harvesting-machine manufacturers adopted the idea, under licence to Appleby.

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1927, 'Twine knotter history', *Wisconsin Magazine of History* (a more specific account).

AP

Applegath, Augustus

fl. 1816–58 London, England

English printer and manufacturer of printing machinery.

After **Koenig** and Bauer had introduced the machine printing-press and returned to Germany, it fell to Applegath and his mechanic brother-in-law Edward Cooper to effect improvements. In particular, Applegath succeeded Koenig and Bauer as machine specialist to *The Times* newspaper, then in the vanguard of printing technology.

Applegath and Cooper first came into prominence when the Bank of England began to seek ways of reducing the number of forged banknotes. In 1816 Cooper patented a device for printing banknotes from curved stereotypes fixed to a cylinder. These were inked and printed by the rotary method. Although Applegath and Cooper were granted money to develop their invention, the Bank did not pursue it. The idea of rotary printing was interesting, but it was not followed up, possibly due to lack of demand.

Applegath and Cooper were then engaged by John Walter of *The Times* to remedy defects in Koenig and Bauer's presses; in 1818 Cooper patented an improved method of inking the forme and Applegath also took out patents for improvements. In 1821 Applegath had enough experience of these presses to set up as a manufacturer of printing machinery in premises in Duke Street, Blackfriars, in London. Increases in the size and circulation of *The Times* led Walter to ask Applegath to build a faster press. In 1827 he produced a machine with the capacity of four presses, his steam-driven four-feeder press.

Its flat form carrying the type passed under four impression cylinders in a row. It could make 4,200 impressions an hour and sufficed to print *The Times* for twenty years, until it was superseded by the rotary press devised by **Hoe**. By 1826, however, Applegath was in financial difficulties; he sold his Duke Street workshop to William Clowes, a book printer. In the following year he gave up being a full-time manufacturer of printing machinery and turned to silk printing. In 1830 he patented a machine for printing rolls of calico and silk from bent intaglio plates.

In 1848 Applegath was persuaded by *The Times* to return to newspaper printing. He tackled rotary printing without the benefit of curved printing plates and roll paper feed, and he devised a large 'type revolving' machine which set the pattern for newspaper printing-presses for some twenty years.

Further Reading

J.Moran, 1973, *Printing Presses*, London: Faber & Faber.

LRD

Appleton, Sir Edward Victor

b. 6 September 1892 Bradford, England

d. 21 April 1965 Edinburgh, Scotland

English physicist awarded the Nobel Prize for Physics for his discovery of the ionospheric layer, named after him, which is an efficient reflector of short radio waves, thereby making possible long-distance radio communication.

After early ambitions to become a professional cricketer, Appleton went to St John's College, Cambridge, where he studied under J.J.Thompson and Ernest Rutherford. His academic career interrupted by the First World War, he served as a captain in the Royal Engineers, carrying out investigations into the propagation and fading of radio signals. After the war he joined the Cavendish Laboratory, Cambridge, as a demonstrator in 1920, and in 1924 he moved to King's College, London, as Wheatstone Professor of Physics.

In the following decade he contributed to developments in valve oscillators (in particular, the 'squegging' oscillator, which formed the basis of the first hard-valve time-base) and gained international recognition for research into electromagnetic-wave propagation. His most important contribution was to confirm the existence of a conducting ionospheric layer in the upper atmosphere capable of reflecting radio waves, which had been predicted almost simultaneously by **Heaviside** and **Kennelly** in 1902. This he did by persuading the BBC in 1924 to vary the frequency of their Bournemouth transmitter, and he then measured the signal received at Cambridge. By comparing the direct and reflected rays and the daily variation he was able to deduce that the Kennelly-Heaviside (the so-called E-layer) was at a height of about 60 miles (97 km) above the

earth and that there was a further layer (the Appleton or F-layer) at about 150 miles (240 km), the latter being an efficient reflector of the shorter radio waves that penetrated the lower layers. During the period 1927–32 and aided by Hartree, he established a magneto-ionic theory to explain the existence of the ionosphere. He was instrumental in obtaining agreement for international co-operation for ionospheric and other measurements in the form of the Second Polar Year (1932–3) and, much later, the International Geophysical Year (1957–8). For all this work, which made it possible to forecast the optimum frequencies for long-distance short-wave communication as a function of the location of transmitter and receiver and of the time of day and year, in 1947 he was awarded the Nobel Prize for Physics.

He returned to Cambridge as Jacksonian Professor of Natural Philosophy in 1939, and with M.F. Barnett he investigated the possible use of radio waves for radio-location of aircraft. In 1939 he became Secretary of the Government Department of Scientific and Industrial Research, a post he held for ten years. During the Second World War he contributed to the development of both radar and the atomic bomb, and subsequently served on government committees concerned with the use of atomic energy (which led to the establishment of Harwell) and with scientific staff.

Principal Honours and Distinctions

Knighted (KCB 1941, GBE 1946). Nobel Prize for Physics 1947. FRS 1927. Vice-President, American Institute of Electrical Engineers 1932. Royal Society Hughes Medal 1933. Institute of Electrical Engineers Faraday Medal 1946. Vice-Chancellor, Edinburgh University 1947. Institution of Civil Engineers Ewing Medal 1949. Royal Medallist 1950. Institute of Electrical and Electronics Engineers Medal of Honour 1962. President, British Association 1953. President, Radio Industry Council 1955–7. Légion d'honneur. LLD University of St Andrews 1947.

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 J.Jewkes, D.Sawers & R.Stillerman, 1958, *The Sources of Invention*.

Archer, Frederick Scott

b. 1813 Bishops Stortford, Hertfordshire, England

d. May 1857 London, England

English photographer, inventor of the wet-collodion process, the dominant photographic process between 1851 and c.1880.

Apprenticed to a silversmith in London, Archer's interest in coin design and sculpture led to his taking up photography in 1847. Archer began experiments to improve **Talbot's** calotype process and by 1848 he was investigating the properties of a newly discovered material, collodion, a solution of gun-cotton in ether. In 1851 Archer published details of a process using collodion on glass plates as a carrier for silver salts. The process combined the virtues of both the calotype and the daguerreotype processes, then widely practised, and soon displaced them from favour. Collodion plates were only sensitive when moist and it was therefore essential to use them immediately after they had been prepared. Popularly known as 'wet plate' photography, it became the dominant photographic process for thirty years.

Archer introduced other minor photographic innovations and in 1855 patented a collodion stripping film. He had not patented the wet-plate process, however, and made no financial gain from his photographic work. He died in poverty in 1857, a matter of some embarrassment to his contemporaries. A subscription fund was raised, to which the Government was subsequently persuaded to add an annual pension.

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JW

Archimedes of Syracuse

b. 287 BC

d. 212 BC

Greek engineer who made the first measurement of specific gravity.

He studied in Alexandria, after which he returned to Syracuse where he spent most of the rest of his life. He made many mathematical discoveries, including the most accurate calculation of π made up to that time. In engineering he was the founder of the science of hydrostatics. He is well known for the discovery of ‘Archimedes’ Law’, that a body wholly or partly immersed in a fluid loses weight equal to the weight of the fluid displaced. He thus made the first measurement of specific gravity.

Archimedes also proved the law of the lever and developed the theory of mechanical advantage, boasting to his cousin Hieron, ‘Give me a place to stand on and with a lever I will move the whole world.’ To prove his point, he launched one of the biggest ships built up to that date. During his time in Egypt, he devised the ‘Archimedean Screw’, still used today in Middle Eastern countries for pumping water. He also built an astronomical instrument to demonstrate the movements of the heavenly bodies, a form of orrery.

He was General of Ordnance to Heiron, and when the Romans besieged Syracuse, a legionary came across Archimedes drawing geometrical diagrams in the sand. Archimedes immediately told him to ‘Keep off and the soldier killed him. He also experimented with burning glasses and mirrors for setting fire to wooden ships.

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L.Sprague de Camp, 1963, *Ancient Engineers*, Souvenir Press.
E.J.Dijksterhuis, 1956, *Archimedes*, Copenhagen: Munksgaard.

IMcN

Arezzo, Guido d’

See **Guido d’Arezzo** .

Argand, François-Pierre Amis

b. 5 July 1750 Geneva, Switzerland
d. October 1803 London, England

Swiss inventor of the Argand lamp.

Son of a clockmaker, he studied physics and chemistry under H.-D. de Saussure (1740–

99). In 1775 he moved to Paris, where he taught chemistry and presented a paper on electrical phenomena to the Académie Royale des Sciences. He assisted the **Montgolfier** brothers in their Paris balloon ascents.

From 1780 Argand spent some time in Montpellier, where he conceived the idea of the lamp that was to make him famous. It was an oil lamp with gravity oil feed, in which the flame was enlarged by burning it in a current of air induced by two concentric iron tubes. It produced ten times the illumination of the simple oil lamp. From the autumn of 1783 to summer 1785, Argand travelled to London and Birmingham to promote the manufacture and sale of his lamp. Upon his return to Paris, he found that his design had been plagiarized; with others, Argand sought to establish his priority, and Paul Abeille published a tract, *Découverte des lampes à courant d'air et à cylindre* (1785). As a result, the Académie granted Argand a licence to manufacture the lamp. However, during the Revolution, Argand's factories were destroyed and his licence annulled. He withdrew to Versoix, near Geneva. In 1793, the English persuaded him to take refuge in England and tried, apparently without success, to obtain recompense for his losses.

Argand is also remembered for his work on distillation and on the water distributor or hydraulic ram, which was conceived with Joseph Montgolfier in 1797 and recognized by the grant of a patent in the same year.

Further Reading

M.Schroder, 1969, *The Armand Burner: Its Origin and Development in France and England, 1781–1800*, Odense University Press.

LRD

Arkwright, Sir Richard

b. 23 December 1732 Preston, England

d. 3 August 1792 Cromford, England

English inventor of a machine for spinning cotton.

Arkwright was the youngest of thirteen children and was apprenticed to a barber; when he was about 18, he followed this trade in Bolton. In 1755 he married Patience Holt, who bore him a son before she died, and he remarried in 1761, to Margaret Biggins. He prospered until he took a public house as well as his barber shop and began to lose money. After this failure, he travelled around buying women's hair for wigs.

In the late 1760s he began spinning experiments at Preston. It is not clear how much Arkwright copied earlier inventions or was helped by Thomas **Highs** and John **Kay** but in 1768 he left Preston for Nottingham, where, with John **Smalley** and David **Thornley** as partners, he took out his first patent. They set up a mill worked by a horse where machine-spun yarn was produced successfully. The essential part of this process lay in

drawing out the cotton by rollers before it was twisted by a flyer and wound onto the bobbin. The partners' resources were not sufficient for developing their patent so Arkwright found new partners in Samuel **Need** and Jedediah **Strutt**, hosiers of Nottingham and Derby. Much experiment was necessary before they produced satisfactory yarn, and in 1771 a water-driven mill was built at Cromford, where the spinning process was perfected (hence the name 'waterframe' was given to his spinning machine); some of this first yarn was used in the hosiery trade. Sales of all-cotton cloth were initially limited because of the high tax on calicoes, but the tax was lowered in 1774 by Act of Parliament, marking the beginning of the phenomenal growth of the cotton industry. In the evidence for this Act, Arkwright claimed that he had spent £12,000 on his machine. Once Arkwright had solved the problem of mechanical spinning, a bottleneck in the preliminary stages would have formed but for another patent taken out in 1775. This covered all preparatory processing, including some ideas not invented by Arkwright, with the result that it was disputed in 1783 and finally annulled in 1785. It contained the 'crank and comb' for removing the cotton web off carding engines which was developed at Cromford and solved the difficulty in carding. By this patent, Arkwright had mechanized all the preparatory and spinning processes, and he began to establish water-powered cotton mills even as far away as Scotland. His success encouraged many others to copy him, so he had great difficulty in enforcing his patent

Need died in 1781 and the partnership with Strutt ended soon after. Arkwright became very rich and financed other spinning ventures beyond his immediate control, such as that with Samuel Oldknow. It was estimated that 30,000 people were employed in 1785 in establishments using Arkwright's patents. In 1786 he received a knighthood for delivering an address of thanks when an attempt to assassinate George III failed, and the following year he became High Sheriff of Derbyshire. He purchased the manor of Cromford, where he died in 1792.

Principal Honours and Distinctions

Knighthood 1786.

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R.L.Hills, 1970, *Power in the Industrial Revolution*, Manchester (discusses the technical problems of Arkwright's invention).

RLH

Armstrong, Edwin Howard

b. 18 December 1890 New York City, New York, USA

d. 31 January 1954 New York City, New York, USA

American engineer who invented the regenerative and superheterodyne amplifiers and frequency modulation, all major contributions to radio communication and broadcasting.

Interested from childhood in anything mechanical, as a teenager Armstrong constructed a variety of wireless equipment in the attic of his parents' home, including spark-gap transmitters and receivers with iron-filing 'coherer' detectors capable of producing weak Morse-code signals. In 1912, while still a student of engineering at Columbia University, he applied positive, i.e. regenerative, feedback to a Lee **De Forest** triode amplifier to just below the point of oscillation and obtained a gain of some 1,000 times, giving a receiver sensitivity very much greater than hitherto possible. Furthermore, by allowing the circuit to go into full oscillation he found he could generate stable continuous-waves, making possible the first reliable CW radio transmitter. Sadly, his claim to priority with this invention, for which he filed US patents in 1913, the year he graduated from Columbia, led to many years of litigation with De Forest, to whom the US Supreme Court finally, but unjustly, awarded the patent in 1934. The engineering world clearly did not agree with this decision, for the Institution of Radio Engineers did not revoke its previous award of a gold medal and he subsequently received the highest US scientific award, the Franklin Medal, for this discovery.

During the First World War, after some time as an instructor at Columbia University, he joined the US Signal Corps laboratories in Paris, where in 1918 he invented the superheterodyne, a major contribution to radio-receiver design and for which he filed a patent in 1920. The principle of this circuit, which underlies virtually all modern radio, TV and radar reception, is that by using a local oscillator to convert, or 'heterodyne', a wanted signal to a lower, fixed, 'intermediate' frequency it is possible to obtain high amplification and selectivity without the need to 'track' the tuning of numerous variable circuits.

Returning to Columbia after the war and eventually becoming Professor of Electrical Engineering, he made a fortune from the sale of his patent rights and used part of his wealth to fund his own research into further problems in radio communication, particularly that of receiver noise. In 1933 he filed four patents covering the use of wide-

band frequency modulation (FM) to achieve low-noise, high-fidelity sound broadcasting, but unable to interest RCA he eventually built a complete broadcast transmitter at his own expense in 1939 to prove the advantages of his system. Unfortunately, there followed another long battle to protect and exploit his patents, and exhausted and virtually ruined he took his own life in 1954, just as the use of FM became an established technique.

Principal Honours and Distinctions

Institution of Radio Engineers Medal of Honour 1917. Franklin Medal 1937. IERE Edison Medal 1942. American Medal for Merit 1947.

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1924, 'The superheterodyne. Its origin, developments and some recent improvements', *Proceedings of the Institute of Radio Engineers* 12:549.
1936, 'A method of reducing disturbances in radio signalling by a system of frequency modulation', *Proceedings of the Institute of Radio Engineers* 24:689.

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J.R.Whitehead, 1950, *Super-regenerative Receivers*.
A.N.Goldsmith, 1948, *Frequency Modulation* (for the background to the development of frequency modulation, in the form of a large collection of papers and an extensive bibliography).

KF

Armstrong, Sir William George, Baron Armstrong of Cragside

- b. 26 November 1810 Shieldfield, Newcastle upon Tyne, England
d. 27 December 1900 Cragside, Northumbria, England

*English inventor, engineer and entrepreneur in hydraulic engineering,
shipbuilding and the production of artillery.*

The only son of a corn merchant, Alderman William Armstrong, he was educated at private schools in Newcastle and at Bishop Auckland Grammar School. He then became an articled clerk in the office of Armorer Donkin, a solicitor and a friend of his father. During a fishing trip he saw a water-wheel driven by an open stream to work a marble-cutting machine. He felt that its efficiency would be improved by introducing the water to the wheel in a pipe. He developed an interest in hydraulics and in electricity, and became a popular lecturer on these subjects. From 1838 he became friendly with Henry Watson of the High Bridge Works, Newcastle, and for six years he visited the Works almost daily, studying turret clocks, telescopes, papermaking machinery, surveying instruments and other equipment being produced. There he had built his first hydraulic machine, which generated 5 hp when run off the Newcastle town water-mains. He then designed and made a working model of a hydraulic crane, but it created little interest. In 1845, after he had served this rather unconventional apprenticeship at High Bridge Works, he was appointed Secretary of the newly formed Whittle Dene Water Company. The same year he proposed to the town council of Newcastle the conversion of one of the quayside cranes to his hydraulic operation which, if successful, should also be applied to a further four cranes. This was done by the Newcastle Cranage Company at High Bridge Works. In 1847 he gave up law and formed W.G. Armstrong & Co. to manufacture hydraulic machinery in a works at Elswick. Orders for cranes, hoists, dock gates and bridges were obtained from mines; docks and railways.

Early in the Crimean War, the War Office asked him to design and make submarine mines to blow up ships that were sunk by the Russians to block the entrance to Sevastopol harbour. The mines were never used, but this set him thinking about military affairs and brought him many useful contacts at the War Office. Learning that two eighteen-pounder British guns had silenced a whole Russian battery but were too heavy to move over rough ground, he carried out a thorough investigation and proposed light field guns with rifled barrels to fire elongated lead projectiles rather than cast-iron balls. He delivered his first gun in 1855; it was built of a steel core and wound-iron wire jacket. The barrel was multi-grooved and the gun weighed a quarter of a ton and could fire a 3 lb (1.4 kg) projectile. This was considered too light and was sent back to the factory to be rebored to take a 5 lb (2.3 kg) shot. The gun was a complete success and Armstrong was then asked to design and produce an equally successful eighteen-pounder. In 1859 he was appointed Engineer of Rifled Ordnance and was knighted. However, there was considerable opposition from the notably conservative officers of the Army who resented the intrusion of this civilian engineer in their affairs. In 1862, contracts with the Elswick Ordnance Company were terminated, and the Government rejected breech-loading and went back to muzzle-loading. Armstrong resigned and concentrated on foreign sales, which were successful worldwide.

The search for a suitable proving ground for a 12-ton gun led to an interest in shipbuilding at Elswick from 1868. This necessitated the replacement of an earlier stone bridge with the hydraulically operated Tyne Swing Bridge, which weighed some 1450 tons and allowed a clear passage for shipping. Hydraulic equipment on warships became more complex and increasing quantities of it were made at the Elswick works, which also flourished with the reintroduction of the breech-loader in 1878. In 1884 an open-hearth acid steelworks was added to the Elswick facilities. In 1897 the firm merged with Sir

Joseph Whitworth & Co. to become Sir W.G.Armstrong Whitworth & Co. After Armstrong's death a further merger with Vickers Ltd formed Vickers Armstrong Ltd.

In 1879 Armstrong took a great interest in Joseph **Swan's** invention of the incandescent electric light-bulb. He was one of those who formed the Swan Electric Light Company, opening a factory at South Benwell to make the bulbs. At Cragside, his mansion at Roth bury, he installed a water turbine and generator, making it one of the first houses in England to be lit by electricity.

Armstrong was a noted philanthropist, building houses for his workforce, and endowing schools, hospitals and parks. His last act of charity was to purchase Bamburgh Castle, Northumbria, in 1894, intending to turn it into a hospital or a convalescent home, but he did not live long enough to complete the work.

Principal Honours and Distinctions

Knighted 1859. FRS 1846. President, Institution of Mechanical Engineers; Institution of Civil Engineers; British Association for the Advancement of Science 1863. Baron Armstrong of Cragside 1887.

Further Reading

E.R.Jones, 1886, *Heroes of Industry*, London: Low.

D.J.Scott, 1962, *A History of Vickers*, London: Weidenfeld & Nicolson.

IMcN

Arnold, Aza

b. 4 October 1788 Smithfield, Pawtucket, Rhode Island, USA

d. 1865 Washington, DC, USA

American textile machinist who applied the differential motion to roving frames, solving the problem of winding on the delicate cotton rovings.

He was the son of Benjamin and Isabel Arnold, but his mother died when he was 2 years old and after his father's second marriage he was largely left to look after himself. After attending the village school he learnt the trade of a carpenter, and following this he became a machinist. He entered the employment of Samuel **Slater**, but left after a few years to engage in the unsuccessful manufacture of woollen blankets. He became involved in an engineering shop, where he devised a machine for taking wool off a carding machine and making it into endless slivers or rovings for spinning. He then became associated with a cotton-spinning mill, which led to his most important invention.

The carded cotton sliver had to be reduced in thickness before it could be spun on the

final machines such as the mule or the waterframe. The roving, as the mass of cotton fibres was called at this stage, was thin and very delicate because it could not be twisted to give strength, as this would not allow it to be drawn out again during the next stage. In order to wind the roving on to bobbins, the speed of the bobbin had to be just right but the diameter of the bobbin increased as it was filled. Obtaining the correct reduction in speed as the circumference increased was partially solved by the use of double-coned pulleys, but the driving belt was liable to slip owing to the power that had to be transmitted.

The final solution to the problem came with the introduction of the differential drive with bevel gears or a sun-and-planet motion. Arnold had invented this compound motion in 1818 but did not think of applying it to the roving frame until 1820. It combined the direct-gearing drive from the main shaft of the machine with that from the cone-drum drive so that the latter only provided the difference between flyer and bobbin speeds, which meant that most of the transmission power was taken away from the belt. The patent for this invention was issued to Arnold on 23 January 1823 and was soon copied in Britain by Henry **Houldsworth**, although J.Green of Mansfield may have originated it independently in the same year. Arnold's patent was widely infringed in America and he sued the Proprietors of the Locks and Canals, machine makers for the Lowell manufacturers, for \$30,000, eventually receiving \$3,500 compensation. Arnold had his own machine shop but he gave it up in 1838 and moved to Philadelphia, where he operated the Mulhausen Print Works. Around 1850 he went to Washington, DC, and became a patent attorney, remaining as such until his death. On 24 June 1856 he was granted patent for a self-setting and self-raking saw for sawing machines.

Bibliography

28 June 1856, US patent no. 15,163 (self-setting and self-raking saw for sawing machines).

Further Reading

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W.English, 1969, *The Textile Industry*, London (a description of the principles of the differential gear applied to the roving frame).

D.J.Jeremy, 1981, *Transatlantic Industrial Revolution. The Diffusion of Textile Technologies Between Britain and America, 1790–1830*, Oxford (a discussion of the introduction and spread of Arnold's gear).

RLH

Arnold, John

b. 1735/6 Bodmin (?), Cornwall, England

d. 25 August 1799 Eltham, London, England

English clock, watch, and chronometer maker who invented the isochronous helical balance spring and an improved form of detached detent escapement.

John Arnold was apprenticed to his father, a watchmaker, and then worked as an itinerant journeyman in the Low Countries and, later, in England. He settled in London in 1762 and rapidly established his reputation at Court by presenting George III with a miniature repeating watch mounted in a ring. He later abandoned the security of the Court for a more precarious living developing his chronometers, with some financial assistance from the Board of Longitude. Symbolically, in 1771 he moved from the vicinity of the Court at St James's to John Adam Street, which was close to the premises of the Royal Society for the Encouragement of Arts, Manufactures & Commerce.

By the time Arnold became interested in chronometry, **Harrison** had already demonstrated that longitude could be determined by means of a timekeeper, and the need was for a simpler instrument that could be sold at an affordable price for universal use at sea. **Le Roy** had shown that it was possible to dispense with a remontoire by using a detached escapement with an isochronous balance; Arnold was obviously thinking along the same lines, although he may not have been aware of Le Roy's work. By 1772 Arnold had developed his detached escapement, a pivoted detent which was quite different from that used on the European continent, and three years later he took out a patent for a compensation balance and a helical balance spring (Arnold used the spring in torsion and not in tension as Harrison had done). His compensation balance was similar in principle to that described by Le Roy and used riveted bimetallic strips to alter the radius of gyration of the balance by moving small weights radially. Although the helical balance spring was not completely isochronous it was a great improvement on the spiral spring, and in a later patent (1782) he showed how it could be made more truly isochronous by shaping the ends. In this form it was used universally in marine chronometers.

Although Arnold's chronometers performed well, their long-term stability was less satisfactory because of the deterioration of the oil on the pivot of the detent. In his patent of 1782 he eliminated this defect by replacing the pivot with a spring, producing the spring detent escapement. This was also done independently at about the same time by Berthoud and Earnshaw, although Earnshaw claimed vehemently that Arnold had plagiarized his work. Ironically it was Earnshaw's design that was finally adopted, although he had merely replaced Arnold's pivoted detent with a spring, while Arnold had completely redesigned the escapement. Earnshaw also improved the compensation balance by fusing the steel to the brass to form the bimetallic element, and it was in this form that it began to be used universally for chronometers and high-grade watches.

As a result of the efforts of Arnold and Earnshaw, the marine chronometer emerged in what was essentially its final form by the end of the eighteenth century. The standardization of the design in England enabled it to be produced economically; whereas Larcum Kendall was paid £500 to copy Harrison's fourth timekeeper, Arnold was able to sell his chronometers for less than one-fifth of that amount. This combination of price and quality led to Britain's domination of the chronometer market during the nineteenth century.

Bibliography

30 December 1775, 'Timekeepers', British patent no. 1,113.

2 May 1782, 'A new escapement, and also a balance to compensate the effects arising from heat and cold in pocket chronometers, and for incurring the ends of the helical spring...', British patent no. 1,382.

Further Reading

R.T.Gould, 1923, *The Marine Chronometer: Its History and Development*, London; reprinted 1960, Holland Press (provides an overview).

V.Mercer, 1972, *John Arnold & Son Chronometer Makers 1726–1843*, London.

See also **Phillips, Edouard**.

DV

Arsonval, Jacques Arsène d'

b. 8 June 1851 Boric, France

d. 31 December 1940 Boric, France

French physician and physicist noted for his invention of the reflecting galvanometer and for contributions to electrotherapy.

After studies at colleges in Limoges and later in Paris, Arsonval became a doctor of medicine in 1877. In 1882 the Collège de France established a laboratory of biophysics with Arsonval as Director, and he was Professor from 1894.

His most outstanding scientific contributions were in the field of biological applications of electricity. His interest in muscle currents led to a series of inventions to assist in research, including the moving-coil galvanometer. In 1881 he made a significant improvement to the galvanometer by reversing the magnetic elements. It had been usual to suspend a compass needle in the centre of a large, stationary coil, but Arsonval's invention was to suspend a small, light coil between the poles of a powerful fixed magnet. This simple arrangement was independent of the earth's magnetic field and insensitive to vibration. A great increase in sensitivity was achieved by attaching a mirror to the coil in order to reflect a spot of light. For bacterial-research purposes he designed the first constant-temperature incubator controlled by electricity. His experiments on the effects of high-frequency, low-voltage alternating currents on animals led to the first high-frequency heat-therapy unit being established in 1892, and later to methods of physiotherapy becoming a professional discipline.

Principal Honours and Distinctions

Académie des Sciences, Prix Montyon 1882. Chevalier de la Légion d'honneur 1884. Grand Cross 1931.

Bibliography

1882, *Comptes rendus de l'Académie des Sciences* 94:1347–50 (describes the galvanometer).
1903, *Traité de physique biologique*, 2 vols, Paris (an account of his technological work).

Further Reading

C.C.Gillispie (ed.), 1970, *Dictionary of Scientific Biography*, Vol. 1, New York, pp. 302–5.
D.O.Woodbury, 1949, *A Measure for Greatness*, New York.

GW

Arup, Sir Ove

b. 16 April 1895 Newcastle upon Tyne, England
d. 5 February 1988 Highgate, London, England

English consultant engineer.

Of Scandinavian parentage, Arup attended school in Germany and Denmark before taking his degree in mathematics and philosophy at Copenhagen University in 1914. He then graduated as a civil engineer from the Royal Technical College in the same city, specializing in the theory of structures.

Arup retained close ties with Europe for some time, working in Hamburg as a designer for the Danish civil engineering firm of Christiani & Nielsen. Then, in the 1930s, he began what was to be a long career in England as an engineering consultant to a number of architects who were beginning to build with modern materials (particularly concrete) and methods of construction. He became consultant to the famous firm of Tecton (under the direction of Berthold **Lubetkin**) and was closely associated with the leading projects of that firm at the time, notably the High-point flats at Highgate, the Finsbury Health Centre and the award-winning Penguin Pool at the Regent's Park Zoological Gardens, all in London.

In 1945 Arup founded his own firm, Ove Arup & Partners, working entirely as a consultant to architects, particularly on structural schemes, and in 1963 he set up a

partnership of architects and engineers, Arup Associates. The many and varied projects with which he was concerned included Coventry Cathedral and the University of Sussex with Sir Basil Spence, the Sydney Opera House with Joern Utzon and St Catherine's College, Oxford, with Arne Jacobsen.

Principal Honours and Distinctions

CBE 1953. Commander of the Order of Danneborg, awarded by King Frederik of Denmark, 1975. Honorary Doctorate Tekniske Hojskole, Lyngby, Denmark 1954. Honorary DSc Durham University 1967, University of East Anglia 1968, Heriot-Watt University 1976. RIBA Gold Medal 1966. Institution of Structural Engineers Gold Medal 1973. Fellow of the American Concrete Institution 1975.

Further Reading

J.M.Richards, 1953, *An Introduction to Modern Architecture*, London: Penguin.
H.Russell-Hitchcock, 1982, *Architecture, Nineteenth and Twentieth Centuries*, London: Pelican.
C.Jencks, 1980, *Late-Modern Architecture*, London: Academy Editions.

DY

Ashley, Howard Matravers

b. 1841
d. 1914 England

English inventor of the semi-automatic bottle-making machine.

Ashley, manager of an iron foundry at Ferrybridge, Yorkshire, began trying to construct a bottle-making machine in the 1880s. In 1886 he obtained a patent for a two-stage machine. This proved to be impracticable, but improvements were described in further patents in 1887 and 1889, leading to a three-stage process, embodying the basic elements of a machine to make narrow-necked glass bottles. The Ashley (Machine-Made) Bottle Company was set up to exploit the invention, but had failed by 1894 due to poor management, although it had claimed to make bottles in a tenth of the time taken to make them by hand. Ashley had shown the way, however, and his machines were still producing good bottles in 1918. The process was a stage along the way to complete mechanization brought about by M.J. **Owens's** machine.

Bibliography

Ashley took out nine British patents during 1886–90, including:
2 July 1886, British patent no. 8,677 (two-stage bottle-making machine).

Further Reading

R.E.Moody, 1985, 'A century of mechanical bottle making', *Glass Technology* 26 (2):
109 ff.

LRD

Aspdin, Joseph

b. 1778 Leeds, England

d. 20 March 1855 Wakefield (?), England

English pioneer in the development of the cement industry.

Joseph Aspdin was the eldest of the six children of Thomas Aspdin, a bricklayer. He became interested in making advanced cements for rendering brickwork and, on 21 October 1824, patented a calcined mixture of limestone, clay and water that he called Portland Cement because he thought it resembled Portland Stone in colour.

Aspdin established his first cement works at Kirkgate in Wakefield in 1825: this was demolished in 1838 due to railway development, and a new works was established in the town in 1843. A year later Joseph Aspdin retired and handed the business over to his elder son James. Meanwhile, William, a younger son of Joseph, had also entered the business of manufacturing cement. Born in Leeds on 23 September 1815, he joined his father's firm at the age of 14, but left in 1841 to set up his own firm at Rotherhithe, London. There he manufactured an improved cement that was better and stronger than **Parker's** Roman Cement, probably because it contained a higher proportion of clinkered material. Further improvements were made during the following years and new factories were established, first at Northfleet in Kent and later at Gateshead on the south bank of the River Tyne (1853). It is interesting that Sir Marc **Brunel** later preferred to use William Aspdin's cement in the Thames railway tunnel construction because of its greater strength (see **Frost**). William Aspdin died at Itzehoe in Germany in 1864.

Further Reading

A.J.Francis, 1977, *The Cement Industry 1796–1914: A History*, David & Charles.

DY

Aspinall, Sir John Audley Frederick

b. 25 August 1851 Liverpool, England

d. 19 January 1937 Woking, England

English mechanical engineer, pioneer of the automatic vacuum brake for railway trains and of railway electrification.

Aspinall's father was a QC, Recorder of Liverpool, and Aspinall himself became a pupil at Crewe Works of the London & North Western Railway, eventually under F.W. **Webb** . In 1875 he was appointed Manager of the works at Inchicore, Great Southern & Western Railway, Ireland. While he was there, some of the trains were equipped, on trial, with continuous brakes of the non-automatic vacuum type. Aspinall modified these to make them automatic, i.e. if the train divided, brakes throughout both parts would be applied automatically. Aspinall vacuum brakes were subsequently adopted by the important Great Northern, Lancashire & Yorkshire, and London & North Western Railways.

In 1883, aged only 32, Aspinall was appointed Locomotive Superintendent of the Great Southern & Western Railway, but in 1886 he moved in the same capacity to the Lancashire & Yorkshire Railway, where his first task was to fit out the new works at Horwich. The first locomotive was completed there in 1889, to his design. In 1899 he introduced a 4-4-2, the largest express locomotive in Britain at the time, some of which were fitted with smokebox superheaters to Aspinall's design.

Unusually for an engineer, in 1892 Aspinall was appointed General Manager of the Lancashire & Yorkshire Railway. He electrified the Liverpool-Southport line in 1904 at 600 volts DC with a third rail; this was an early example of main-line electrification, for it extended beyond the Liverpool suburban area. He also experimented with 3,500 volt DC overhead electrification of the Bury-Holcombe Brook branch in 1913, but converted this to 1,200 volts DC third rail to conform with the Manchester-Bury line when this was electrified in 1915. In 1918 he was made a director of the Lancashire & Yorkshire Railway.

Principal Honours and Distinctions

Knighted 1917. President, Institution of Mechanical Engineers 1909. President, Institution of Civil Engineers 1918.

Further Reading

H.A.V.Bulleid, 1967, *The Aspinall Era* , Shepperton: Ian Allan (provides a good account of Aspinall and his life's work).

C.Hamilton Ellis, 1958, *Twenty Locomotive Men* , Shepperton: Ian Allan , Ch. 19 (a good

brief account).

See also **Gresley, Sir Herbert Nigel** ;
Schmidt, Wilhelm ; **Westinghouse, George** .

PJGR

Atwood, George

b. 1746 England

d. July 1807 London, England

English mathematician author of a theory on ship stability.

Atwood was educated at Westminster School and entered Trinity College, Cambridge, in 1765 with a scholarship. He graduated with high honours (third wrangler) in 1796, and went on to become a fellow and tutor of his college. In 1776 he was elected Fellow of the Royal Society. Eight years later, William Pitt the Younger (1759–1806) appointed him a senior officer of the Customs, this being a means of reimbursing him for the arduous and continuing task of calculating the national revenue. As a lecturer he was greatly renowned and his abilities as a calculator and as a musician were of a high order.

In the late 1790s Atwood presented a paper to the Royal Society that showed a means of obtaining the righting lever on a ship inclined from the vertical; this was a major step forward in the study of ship stability. Among his other inventions was a machine to exhibit the accelerative force of gravity.

Principal Honours and Distinctions

FRS 1776.

Further Reading

A.M.Robb, 1952, *Theory of Naval Architecture* , London: Charles Griffin (for a succinct description of the various factors in ship stability, and the importance of Atwood's contribution).

FMW

Aubert, Jean

b. 7 February 1894 Paris, France

25 November 1984 Paris, France

French civil engineer.

Aubert was educated at the Lycée Louis-leGrand in Paris, and entered the Ecole Polytechnique in 1913. His studies were interrupted by the First World War, when he served as an artillery officer, being wounded twice and awarded the Croix de Guerre in 1916. He returned to the Ecole Polytechnique in 1919, and from 1920 to 1922 he attended the Ecole Nationale des Ponts et Chaussées; he graduated as Bachelor of Law from the University of Paris.

In 1922 he began his long career, devoted principally to river and canal works. He was engineer in charge of the navigation works in Paris until 1932; he was then appointed Professor in the Chair of Internal Navigation at the Ecole des Ponts et Chaussées, a post he held until his retirement in 1961. From 1933 to 1945 he was general manager and later chairman of the Compagnie Nationale du Rhône; from 1945 to 1953, chairman of the electricity board of the Société Nationale des Chemins de Fer français; and from 1949 to 1967, chairman of the Rhine Navigation Company. Following his retirement, he was chairman of the Société des Constructions des Batignolles, and from 1966 consulting engineer and honorary chairman of SPIE Batignolles; he was also chairman of several other companies.

In 1919 he published *La Probabilité dans les tirs de guerre*, for which he was awarded the Pierson-Perrin prize by the Académie des Sciences in 1922. During his career he wrote numerous articles and papers on technical and economic subjects, his last, entitled 'Philosophic de la pente d'eau', appearing in the journal *Travaux* in 1984 when he was ninety years old.

Aubert's principal works included the construction of the Pont Edouard-Herriot on the Rhône at Lyon; the design and construction of the Génissiat and Lonzères-Mondragon dams on the Rhône; and the conception and design of the Denouval dam on the Seine near Andresy, completed in 1980. He was awarded the Caméré prize in 1934 by the Académie des Sciences for a new type of movable dam. Overseas governments and the United Nations consulted him on river navigation *inter alia* in Brazil, on the Mahanadi river in India, on the Konkomé river in Guinea, on the Vistula river in Poland, on the Paraguay river in South America and others.

In 1961 he published his revolutionary ideas on the *pente d'eau*, or 'water slope', which was designed to eliminate delays and loss of water in transferring barges from one level to another, without the use of locks. This design consisted of a sloping flume or channel through which a wedge of water, in which the barge was floating, was pushed by a powered unit. A prototype at Mon tech on the Canal Latéral at La Garonne, bypassing five locks, was opened in 1973. A second was opened in 1984 on the Canal du Midi at Fonsérannes, near Béziers.

Principal Honours and Distinctions

Croix de Guerre 1916. Académie des Sciences: Prix Pierson-Perrin 1922, Prix Caméré 1934. Ingénieur Général des Ponts et Chaussées 1951. Commandeur de la Légion d'honneur 1960.

Further Reading

David Tew, 1984, *Canal Inclines and Lifts*, Gloucester: Alan Sutton.

JHB

Auenbrugger, Leopold Elder von

b. 19 November 1722 Graz, Austria

d. 18 May 1809 Vienna, Austria

Austrian physician and the first to describe percussion as an aid to diagnosis of diseases of the chest.

The son of an innkeeper, Auenbrugger had originally learned to use percussion to ascertain the level of wine in casks. When later he became Physician to the Military Hospital of Vienna, he developed the technique, stating in the monograph that he published on the subject, 'I here present the reader with a new sign which I have discovered for detecting disease of the chest. It consists in percussion of the human thorax whereby...an opinion is formed of the internal state of that cavity'. The monograph attracted little attention until some twenty years later. Jean Corvisart, personal physician to Napoleon, translated it into French in 1808, giving full credit to its original author. Auenbrugger also had some musical expertise, and with Salieri composed an opera for Maria Theresa.

Principal Honours and Distinctions

Ennobled 1784.

Bibliography

1761, *Inventum novum ex percussione thoracis humani ut signo abstrusos interni pectoris morbos detegendi*, Vienna.

Further Reading

J.Forbes (trans.), 1936, 'On percussion of the chest; a translation of Auenbrugger's original treatise', *Bulletin of the History of Medicine*.

Z.Cope, 1957, *Sidelights on the History of Medicine*, London.

MG

Austin, Herbert, Baron Austin

b. 8 November 1866 Little Missenden, Buckinghamshire, England

d. 23 May 1941 Lickey Grange, near Bromsgrove, Herefordshire, England

English manufacturer of cars.

The son of Stephen (or Steven) Austin, a farmer of Wentworth, Yorkshire, he was educated at Rotherham Grammar School and then went to Australia with an uncle in 1884. There he became apprenticed as an engineer at the Langlands Foundry in Melbourne. He moved to the Wolseley Sheep Shearing Company, and soon after became its Manager; in 1893 he returned to England, where he became Production Manager to the English branch of the same company in Birmingham. The difficulties of travel in Australia gave him an idea of the advantages of motor-driven vehicles, and in 1895 he produced the first Wolseley car. In 1901 he was appointed to the Wolseley board, and from 1911 he was Chairman.

His first car was a three-wheeler. An improved model was soon available, and in 1901 the Wolseley company took over the machine tool and motor side of Vickers Sons and Maxim and traded under the name of the Wolseley Tool and Motor Car Company. Herbert Austin was the General Manager. In 1905 he decided to start his own company and formed the Austin Motor Company Ltd, with works at Longbridge, near Birmingham. With a workforce of 270, the firm produced 120 cars in 1906; by 1914 a staff of 2,000 were producing 1,000 cars a year. The First World War saw production facilities turned over to the production of aeroplanes, guns and ammunition.

Peacetime brought a return to car manufacture, and 1922 saw the introduction of the 7 hp 'Baby Austin', a car for the masses. Many other models followed. By 1937 the original Longbridge factory had grown to 220 acres, and the staff had increased to over 16,000, while the number of cars produced had grown to 78,000 per year.

Herbert Austin was a philanthropist who endowed many hospitals and not a few universities; he was created a Baron in 1936.

Principal Honours and Distinctions

Baron 1936.

Further Reading

1941, *Austin Magazine* (June).

Austin, John

fl. 1789 Scotland

Scottish contributor to the early development of the power loom.

On 6 April 1789 John Austin wrote to James **Watt**, seeking advice about patenting ‘a weaving loom I have invented to go by the hand, horse, water or any other constant power, to comb, brush, or dress the yarn at the same time as it is weaving & by which one man will do the work of three and make superior work to what can be done by the common loom’ (Boulton & Watt Collection, Birmingham, James Watt Papers, JW/22). Watt replied that ‘there is a Clergyman by the name of Cartwright at Doncaster who has a patent for a similar contrivance’ (Boulton & Watt Collection, Birmingham, Letter Book 1, 15 April 1789). Watt pointed out that there was a large manufactory running at Doncaster and something of the same kind at Manchester with working power looms. Presumably, this reply deterred Austin from taking out a patent. However, some members of the Glasgow Chamber of Commerce continued developing the loom, and in 1798 one that was tried at the spinning mill of J.Monteith, of Pollokshaws, near Glasgow, answered the purpose so well that a building was erected and thirty of the looms were installed. Later, in 1800, this number was increased to 200, all of which were driven by a steam engine, and it was stated that one weaver and a boy could tend from three to five of these looms.

Austin’s loom was worked by eccentrics, or cams. There was one cam on each side with ‘a sudden beak or projection’ that drove the levers connected to the picking pegs, while other cams worked the heddles and drove the reed. The loom was also fitted with a weft stop motion and could produce more cloth than a hand loom, and worked at about sixty picks per minute. The pivoting of the slay at the bottom allowed the loom to be much more compact than previous ones.

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 W.English, 1969, *The Textile Industry*, London.
 R.L.Hills, 1970, *Power in the Industrial Revolution*, Manchester.
 See also **Cartwright, Revd Edmund**.

RLH

Ayre, Sir Amos Lowrey

b. 23 July 1885 South Shields, England

d. 13 January 1952 London, England

*English shipbuilder and pioneer of the inter-war 'economy' freighters;
Chairman of the Shipbuilding Conference.*

Amos Ayre grew up on the Tyne with the stimulus of shipbuilding and seafaring around him. After an apprenticeship as a ship draughtsman and distinction in his studies, he held responsible posts in the shipyards of Belfast and later Dublin. His first dramatic move came in 1909 when he accepted the post of Manager of the new Employment Exchange at Govan, then just outside Glasgow. During the First World War he was in charge of fleet coaling operations on the River Forth, and later was promoted Admiralty District Director for shipyard labour in Scotland.

Before the conclusion of hostilities, with his brother Wilfrid (later Sir Wilfrid Ayre) he founded the Burntisland Shipbuilding Company in Fife. Setting up on a green field site allowed the brothers to show innovation in design, production and marketing. Such was their success that the new yard was busy throughout the Depression, building standard ships which incorporated low operating costs with simplicity of construction.

Through public service culminating in the 1929 Safety of Life at Sea Conference, Amos Ayre became recognized not only as an eminent naval architect, but also as a skilled negotiator. In 1936 he was invited to become Chairman of the Shipbuilding Conference and thereby virtual leader of the industry. As war approached he planned with meticulous care the rearrangement of national shipbuilding capacity, enabling Britain to produce standard hulls ranging from the legendary TID tugs to the standard freighters built in Sunderland or Port Glasgow. In 1939 he became Director of Merchant Shipbuilding, a position he held until 1944, when with typical foresight he asked to be released to plan for shipbuilding's return to normality.

Principal Honours and Distinctions

Knighthed 1937. KBE 1943. Officer of the Order of Orange-Nassau.

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 James Reid, 1964, *James Lithgow, Master of Work*, London.
 Maurice E.Denny, 1955, 'The man and his work' (First Amos Ayre Lecture),
Transactions of the Institution of Naval Architects vol. 97.

FMW

Ayrton, William Edward

- b. 14 September 1847 London, England
 d. 8 November 1908 London, England

English physicist, inventor and pioneer in technical education.

After graduating from University College, London, Ayrton became for a short time a pupil of Sir William **Thomson** in Glasgow. For five years he was employed in the Indian Telegraph Service, eventually as Superintendent, where he assisted in revolutionizing the system, devising methods of fault detection and elimination. In 1873 he was invited by the Japanese Government to assist as Professor of Physics and Telegraphy in founding the Imperial College of Engineering in Tokyo. There he created a teaching laboratory that served as a model for those he was later to organize in England and which were copied elsewhere. It was in Tokyo that his joint researches with Professor John **Perry** began, an association that continued after their return to England. In 1879 he became Professor of Technical Physics at the City and Guilds Institute in Finsbury, London, and later was appointed Professor of Physics at the Central Institution in South Kensington.

The inventions of Ayrton and Perry included an electric tricycle in 1882, the first practicable portable ammeter and other electrical measuring instruments. By 1890, when the research partnership ended, they had published nearly seventy papers in their joint names, the emphasis being on a mathematical treatment of subjects including electric motor design, construction of electrical measuring instruments, thermodynamics and the economical use of electric conductors. Ayrton was then employed as a consulting engineer by government departments and acted as an expert witness in many important patent cases.

Principal Honours and Distinctions

FRS 1881. President, Physical Society 1890–2. President, Institution of Electrical Engineers 1892. Royal Society Royal Medal 1901.

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G.Gooday, 1991, *History of Technology*, 13: 73–111 (for an account of Ayrton and the teaching laboratory).

GW

B

Babbage, Charles

- b. 26 December 1791 Walworth, Surrey, England
d. 18 October 1871 London, England

English mathematician who invented the forerunner of the modern computer.

Charles Babbage was the son of a banker, Benjamin Babbage, and was a sickly child who had a rather haphazard education at private schools near Exeter and later at Enfield. Even as a child, he was inordinately fond of algebra, which he taught himself. He was conversant with several advanced mathematical texts, so by the time he entered Trinity College, Cambridge, in 1811, he was ahead of his tutors. In his third year he moved to Peterhouse, whence he graduated in 1814, taking his MA in 1817. He first contributed to the *Philosophical Transactions of the Royal Society* in 1815, and was elected a fellow of that body in 1816. He was one of the founders of the Astronomical Society in 1820 and served in high office in it.

While he was still at Cambridge, in 1812, he had the first idea of calculating numerical tables by machinery. This was his first difference engine, which worked on the principle of repeatedly adding a common difference. He built a small model of an engine working

on this principle between 1820 and 1822, and in July of the latter year he read an enthusiastically received note about it to the Astronomical Society. The following year he was awarded the Society's first gold medal. He submitted details of his invention to Sir Humphry **Davy**, President of the Royal Society; the Society reported favourably and the Government became interested, and following a meeting with the Chancellor of the Exchequer Babbage was awarded a grant of £1,500. Work proceeded and was carried on for four years under the direction of Joseph **Clement**.

In 1827 Babbage went abroad for a year on medical advice. There he studied foreign workshops and factories, and in 1832 he published his observations in *On the Economy of Machinery and Manufactures*. While abroad, he received the news that he had been appointed Lucasian Professor of Mathematics at Cambridge University. He held the Chair until 1839, although he neither resided in College nor gave any lectures. For this he was paid between £80 and £90 a year!

Differences arose between Babbage and Clement. Manufacture was moved from Clement's works in Lambeth, London, to new, fireproof buildings specially erected by the Government near Babbage's house in Dorset Square, London. Clement made a large claim for compensation and, when it was refused, withdrew his workers as well as all the special tools he had made up for the job. No work was possible for the next fifteen months, during which Babbage conceived the idea of his 'analytical engine'. He approached the Government with this, but it was not until eight years later, in 1842, that he received the reply that the expense was considered too great for further backing and that the Government was abandoning the project. This was in spite of the demonstration and perfectly satisfactory operation of a small section of the analytical engine at the International Exhibition of 1862. It is said that the demands made on manufacture in the production of his engines had an appreciable influence in improving the standard of machine tools, whilst similar benefits accrued from his development of a system of notation for the movements of machine elements. His opposition to street organ-grinders was a notable eccentricity; he estimated that a quarter of his mental effort was wasted by the effect of noise on his concentration.

Principal Honours and Distinctions

FRS 1816. Astronomical Society Gold Medal 1823.

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Babbage wrote eighty works, including:

1864, *Passages from the Life of a Philosopher*.

1832, *On the Economy of Manufacture and Machinery*.

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IMcN

Bachelier, Nicolas

b. 1485

d. prior to December 1557 Toulouse, France

French surveyor, architect and mason.

Between 1515 and 1522 Francis I of France became ruler of part of Italy, including Milan. He discussed with Leonardo da Vinci the possibility of providing canals in France similar to those constructed or under construction in Italy. One idea was to provide a link between the Garonne at Toulouse and the Aude at Carcassonne. In 1539 Bachelier and his colleague Arnaud Casanove, who described themselves as ‘expert levellers’, proposed a survey of the Toulouse to Carcassonne route and also suggested that barges could either float down the Garonne to Bordeaux or could travel along a canal dug parallel to the river. Francis I authorized them to do the work and approved the plans, which comprised a lock-free canal of variable depth, when they had completed them. However, their plans were hopelessly inaccurate, and nothing was done. In 1598 Henri IV re-examined the plans, but it was left to Pierre Paul **Riquet** in 1662 to reassess the concept of a Biscay-to-Mediterranean waterway.

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JHB

Bacon, Francis Thomas

b. 21 December 1904 Billericay, England

d. 24 May 1992 Little Shelford, Cambridge, England

English mechanical engineer, a pioneer in the modern phase of fuel-cell development.

After receiving his education at Eton and Trinity College, Cambridge, Bacon served with C.A. **Parsons** at Newcastle upon Tyne from 1925 to 1940. From 1946 to 1956 he carried out research on Hydrox fuel cells at Cambridge University and was a consultant on fuel-cell design to a number of organizations throughout the rest of his life.

Sir William **Grove** was the first to observe that when oxygen and hydrogen were supplied to platinum electrodes immersed in sulphuric acid a current was produced in an external circuit, but he did not envisage this as a practical source of electrical energy. In the 1930s Bacon started work to develop a hydrogen-oxygen fuel cell that operated at moderate temperatures and pressures using an alkaline electrolyte. In 1940 he was appointed to a post at King's College, London, and there, with the support of the Admiralty, he started full-time experimental work on fuel cells. His brief was to produce a power source for the propulsion of submarines. The following year he was posted as a temporary experimental officer to the Anti-Submarine Experimental Establishment at Fairlie, Ayrshire, and he remained there until the end of the Second World War.

In 1946 he joined the Department of Chemical Engineering at Cambridge, receiving a small amount of money from the Electrical Research Association. Backing came six years later from the National Research and Development Corporation (NRDC), the development of the fuel cell being transferred to Marshalls of Cambridge, where Bacon was appointed Consultant.

By 1959, after almost twenty years of individual effort, he was able to demonstrate a 6 kW (8 hp) power unit capable of driving a small truck. Bacon appreciated that when substantial power was required over long periods the hydrogen-oxygen fuel cell associated with high-pressure gas storage would be more compact than conventional secondary batteries.

The development of the fuel-cell system pioneered by Bacon was stimulated by a particular need for a compact, lightweight source of power in the United States space programme. Electro-chemical generators using hydrogen-oxygen cells were chosen to provide the main supplies on the Apollo spacecraft for landing on the surface of the moon in 1969. An added advantage of the cells was that they simultaneously provided water. NRDC was largely responsible for the formation of Energy Conversion Ltd, a company that was set up to exploit Bacon's patents and to manufacture fuel cells, and which was supported by British Ropes Ltd, British Petroleum and Guest, Keen & Nettlefold Ltd at Basingstoke. Bacon was their full-time consultant. In 1971 Energy Conversion's operation was moved to the UK Atomic Energy Research Establishment at Harwell, as Fuel Cells Ltd. Bacon remained with them until he retired in 1973.

Principal Honours and Distinctions

OBE 1967. FRS 1972. Royal Society S.G. Brown Medal 1965. Royal Aeronautical Society British Silver Medal 1969.

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 GW

Baekeland, Leo Hendrik

- b. 14 November 1863 Saint-Martens-Latern, Belgium
 d. 23 February 1944 Beacon, New York, USA

Belgian/American inventor of the Velox photographic process and the synthetic plastic Bakélite.

The son of an illiterate shoemaker, Baekeland was first apprenticed in that trade, but was encouraged by his mother to study, with spectacular results. He won a scholarship to Gand University and graduated in chemistry. Before he was 21 he had achieved his doctorate, and soon afterwards he obtained professorships at Bruges and then at Gand. Baekeland seemed set for a distinguished academic career, but he turned towards the industrial applications of chemistry, especially in photography.

Baekeland travelled to New York to further this interest, but his first inventions met with little success so he decided to concentrate on one that seemed to have distinct commercial possibilities. This was a photographic paper that could be developed in artificial light; he called this 'gas light' paper Velox, using the less sensitive silver chloride as a light-sensitive agent. It proved to have good properties and was easy to use, at a time of photography's rising popularity. By 1896 the process began to be profitable, and three years later Baekeland disposed of his plant to Eastman Kodak for a handsome sum, said to be \$3–4 million. That enabled him to retire from business and set up a laboratory at Yonkers to pursue his own research, including on synthetic resins. Several chemists had earlier obtained resinous products from the reaction between phenol and formaldehyde but had ignored them. By 1907 Baekeland had achieved sufficient control over the reaction to obtain a good thermosetting resin which he called 'Bakélite'. It

showed good electrical insulation and resistance to chemicals, and was unchanged by heat. It could be moulded while plastic and would then set hard on heating, with its only drawback being its brittleness. Bakelite was an immediate success in the electrical industry and Baekeland set up the General Bakelite Company in 1910 to manufacture and market the product. The firm grew steadily, becoming the Bakélite Corporation in 1924, with Baekeland still as active President.

Principal Honours and Distinctions

President, Electrochemical Society 1909. President, American Chemical Society 1924. Elected to the National Academy of Sciences 1936.

Further Reading

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A.R.Matthis, 1948, *Leo H.Baekeland, Professeur, Docteur ès Sciences, chimiste, inventeur et grand industriel*, Brussels.

J.K.Mumford, 1924, *The Story of Bakélite*.

C.F.Kettering, 1947, memoir on Baekeland, *Biographical Memoirs of the National Academy of Sciences* 24 (includes a list of his honours and publications).

LRD

Bailey, Sir Donald Coleman

b. 15 September 1901 Rotherham, Yorkshire, England

d. 5 May 1985 Bournemouth, Dorset, England

English engineer, designer of the Bailey bridge.

Bailey was educated at the Leys School, Cambridge, before going to Sheffield University where he studied for a degree in engineering. He joined the Civil Service in 1928 and was posted to the staff of the Experimental Bridging Establishment of the Ministry of Supply at Christchurch, Hampshire. There he continued his boyhood hobby of making model bridges of wood and string. He evolved a design for a prefabricated metal bridge assembled from welded panels linked by pinned joints; this became known as the Bailey bridge. Its design was accepted by the War Office in 1941 and from then on it was used throughout the subsequent conflict of the Second World War. It was a great improvement on its predecessor, the Inglis bridge, designed by a Cambridge University professor of engineering, Charles Inglis, with tubular members that were 10 or 12 ft (3.66 m) long; this bridge was notoriously difficult to construct, particularly in adverse weather conditions, whereas the Bailey bridge's panels and joints were far more manageable and easy to assemble. The simple and standardized component parts of the Bailey bridge

made it highly adaptable: it could be strengthened by increasing the number of truss girders, and wide rivers could be crossed by a series of Bailey bridges connected by pontoons. Field Marshal Montgomery is recorded as saying that without the Bailey bridge we should not have won the war’.

Principal Honours and Distinctions

Knighted 1946.

Further Reading

Obituary, 1985, *The Guardian* 6 May.

IMcN

Bain, Alexander

b. October 1810 Watten, Scotland

d. 2 January 1877 Kirkintilloch, Scotland

Scottish inventor and entrepreneur who laid the foundations of electrical horology and designed an electromagnetic means of transmitting images (facsimile).

Alexander Bain was born into a crofting family in a remote part of Scotland. He was apprenticed to a watchmaker in Wick and during that time he was strongly influenced by a lecture on ‘Heat, sound and electricity’ that he heard in nearby Thurso. This lecture induced him to take up a position in Clerkenwell in London, working as a journeyman clockmaker, where he was able to further his knowledge of electricity by attending lectures at the Adelaide Gallery and the Polytechnic Institution. His thoughts naturally turned to the application of electricity to clockmaking, and despite a bitter dispute with Charles **Wheatstone** over priority he was granted the first British patent for an electric clock. This patent, taken out on 11 January 1841, described a mechanism for an electric clock, in which an oscillating component of the clock operated a mechanical switch that initiated an electromagnetic pulse to maintain the regular, periodic motion. This principle was used in his master clock, produced in 1845. On 12 December of the same year, he patented a means of using electricity to control the operation of steam railway engines via a steam-valve. His earliest patent was particularly far-sighted and anticipated most of the developments in electrical horology that occurred during the nineteenth century. He proposed the use of electricity not only to drive clocks but also to distribute time over a distance by correcting the hands of mechanical clocks, synchronizing pendulums and using slave dials (here he was anticipated by Steinheil). However, he was less successful

in putting these ideas into practice, and his electric clocks proved to be unreliable. Early electric clocks had two weaknesses: the battery; and the switching mechanism that fed the current to the electromagnets. Bain's earth battery, patented in 1843, overcame the first defect by providing a reasonably constant current to drive his clocks, but unlike **Hipp** he failed to produce a reliable switch.

The application of Bain's numerous patents for electric telegraphy was more successful, and he derived most of his income from these. They included a patent of 12 December 1843 for a form of fax machine, a chemical telegraph that could be used for the transmission of text and of images (facsimile). At the receiver, signals were passed through a moving band of paper impregnated with a solution of ammonium nitrate and potassium ferrocyanide. For text, **Morse** code signals were used, and because the system could respond to signals faster than those generated by hand, perforated paper tape was used to transmit the messages; in a trial between Paris and Lille, 282 words were transmitted in less than one minute. In 1865 the Abbé Caselli, a French engineer, introduced a commercial fax service between Paris and Lyons, based on Bain's device. Bain also used the idea of perforated tape to operate musical wind instruments automatically. Bain squandered a great deal of money on litigation, initially with Wheatstone and then with Morse in the USA. Although his inventions were acknowledged, Bain appears to have received no honours, but when towards the end of his life he fell upon hard times, influential persons in 1873 secured for him a Civil List Pension of £80 per annum and the Royal Society gave him £150.

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Further Reading

- The best account of Bain's life and work is in papers by C.A.Aked in *Antiquarian Horology*: 'Electricity, magnetism and clocks' (1971) 7: 398–415; 'Alexander Bain, the father of electrical horology' (1974) 9:51–63; 'An early electric turret clock' (1975) 7:428–42. These papers were reprinted together (1976) in *A Conspectus of Electrical Timekeeping*, Monograph No. 12, Antiquarian Horological Society: Tilehurst.
 J.Finlaison, 1834, *An Account of Some Remarkable Applications of the Electric Fluid to the Useful Arts by Alexander Bain*, London (a contemporary account between Wheatstone and Bain over the invention of the electric clock).
 J.Munro, 1891, *Heroes of the Telegraph*, Religious Tract Society.
 J.Malster & M.J.Bowden, 1976, 'Facsimile. A Review', *Radio & Electronic Engineer* 46:55.

D.J.Weaver, 1982, *Electrical Clocks and Watches*, Newnes.

T.Hunkin, 1993, 'Just give me the fax', *New Scientist* (13 February):33–7 (provides details of Bain's and later fax devices).

See also **Bakewell, Frederick C.**

DV/KF

Baird, John Logie

b. 13 August 1888 Helensburgh, Dumbarton, Scotland

d. 14 June 1946 Bexhill-on-Sea, Sussex, England

Scottish inventor of mechanically-based television.

Baird attended Larchfield Academy, then the Royal Technical College and Glasgow University. However, before he could complete his electrical-engineering degree, the First World War began, although poor health kept him out of the armed services.

Employed as an engineer at the Clyde Valley Electrical Company, he lost his position when his diamond-making experiment caused a power failure in Glasgow. He then went to London, where he lived with his sister and tried manufacturing household products of his own design. To recover from poor health, he then went to Hastings and, using scrap materials, began experiments with imaging systems. In 1924 he transmitted outline images over wires, and by 1925 he was able to transmit recognizable human faces. In 1926 he was able to transmit moving images at a resolution of thirty lines per image and a frequency of ten images per second over an infrared link. Also that year, he started the world's first television station, which he named 2TV. In 1927 he transmitted moving images from London to Glasgow, and later that year to a passenger liner. In 1928 he demonstrated colour television.

In 1936, when the BBC wanted to begin television service, Baird's system lost out in a competition with Marconi Electric and Musical Industries (EMI). In 1946 Baird reported that he had successfully completed research on a stereo television system.

Further Reading

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J.Rowland, 1967, *The Television Man: The Story of John Logie Baird*, New York: Roy Publishers.

F.Macgregor, 1984, *Famous Scots*, Gordon Wright (contains a short biography on Baird).

HO

Bakewell, Frederick C.

fl.1850s

British inventor of the 'copying telegraph', the basis of facsimile transmission.

Although little appears to be known about his life, Bakewell deserves a place in this dictionary for a single invention that was to have a significant impact upon communication. The invention of photography early in the nineteenth century soon led to a desire to transmit images over a distance. Although telegraphy was still very much in its infancy, Bakewell realized that the key to a viable system of facsimile, as it came to be known, was to dissect the image to be transmitted sequentially by scanning it in a series of parallel lines with some sort of sensor and to synchronously reconstruct it at the receiving end—a process that anticipated the way in which modern television works. To this end the line image was drawn with varnish on a sheet of tin foil, which was then wrapped around a cylinder. As the cylinder was rotated, presumably by some kind of regulated clockwork mechanism similar to that used later in the early phonographs of **Edison**, an electrical contact driven by a screw thread caused the image to be scanned along a spiral path, giving a series of on-off signals. At the receiving end, instead of the tin foil, a sheet of paper wetted with a suitable chemical was darkened by the current pulses as they arrived.

A practicable system did not become possible until a dry form of receiving-paper that was insensitive to light became available in the 1930s; once established, however, the technique remained the basis of commercial machines into the 1980s.

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Further Reading

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See also **Bain, Alexander**.

KF

Bakewell, Robert

b. 23 May 1725 Loughborough, England

d. 1 October 1795 Loughborough, England

English livestock breeder who pioneered the practice of progeny testing for selecting breeding stock; he is particularly associated with the development of the Improved Leicester breed of sheep.

Robert Bakewell was the son of the tenant farming the 500-acre (200 hectare) Dishley Grange Farm, near Loughborough, where he was born. The family was sufficiently wealthy to allow Robert to travel, which he began to do at an early age, exploring the farming methods of the West Country, Norfolk, Ireland and Holland. On taking over the farm he continued the development of the irrigation scheme begun by his father. Arthur **Young** visited the farm during his tour of east England in 1771. At that time it consisted of 440 acres (178 hectares), 110 acres (45 hectares) of which were arable, and carried a stock of 60 horses, 400 sheep and 150 other assorted beasts. Of the arable land, 30 acres (12 hectares) were under root crops, mainly turnips.

Bakewell was not the first to pioneer selective breeding, but he was the first successfully to apply selection to both the efficiency with which an animal utilized its food, and its physical appearance. He always had a clear idea of the animal he wanted, travelled extensively to collect a range of animals possessing the characteristics he sought, and then bred from these towards his goal. He was aware of the dangers of inbreeding, but would often use it to gain the qualities he wanted. His early experiments were with Longhorn cattle, which he developed as a meat rather than a draught animal, but his most famous achievement was the development of the Improved Leicester breed of sheep. He set out to produce an animal that would put on the most meat in the least time and with the least feeding. As his base he chose the Old Leicester, but there is still doubt as to which other breeds he may have introduced to produce the desired results. The Improved Leicester was smaller than its ancestor, with poorer wool quality but with greatly improved meat-production capacity.

Bakewell let out his sires to other farms and was therefore able to study their development under differing conditions. However, he made stringent rules for those who hired these animals, requiring the exclusive use of his rams on the farms concerned and requiring particular dietary conditions to be met. To achieve this control he established the Dishley Society in 1783. Although his policies led to accusations of closed access to his stock, they enabled him to keep a close control of all offspring. He thereby pioneered the process now recognized as 'progeny testing'.

Bakewell's fame and that of his farm spread throughout the country and overseas. He engaged in an extensive correspondence and acted as host to all of influence in British and overseas agriculture, but it would appear that he was an over-generous host, since he is known to have been in financial difficulties in about 1789. He was saved from

bankruptcy by a public subscription raised to allow him to continue with his breeding experiments; this experience may well have been the reason why he was such a staunch advocate of State funding of agricultural research.

Further Reading

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 H.C.Parsons, 1957, *Robert Bakewell* (contains a more detailed account).
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 —*A History of British Livestock Husbandry 1700 to 1900* (places Bakewell within the context of overall developments).
 M.L.Ryder, 1983, *Sheep and Man*, Duckworth (a scientifically detailed account which deals with Bakewell within the context of its particular subject).

AP

Baldwin, Matthias William

- b. 10 November 1795 Elizabethtown, New Jersey, USA
 d. 7 September 1866 Philadelphia, Pennsylvania, USA

American builder of steam locomotives, founder of Baldwin Locomotive Works.

After apprenticeship as a jeweller, Baldwin set up a machinery manufacturing business, and built stationary steam engines and, in 1832, his first locomotive, *Old Ironsides*, for the then-new Philadelphia, Germantown & Norristown Railroad. *Old Ironsides* achieved only 1 mph (1.6 km/h) on trial, but after experimentation reached 28 mph (45 km/h). Over the next ten years Baldwin built many stationary engines and ten more locomotives, and subsequently built locomotives exclusively.

He steadily introduced detail improvements in locomotive design; standardized components by means of templates and gauges from 1838 onwards; introduced the cylinder cast integrally with half of the smokebox saddle in 1858; and in 1862 imported steel tyres, which had first been manufactured in Germany by **Krupp** of Essen in 1851, and began the practice in the USA of shrinking them on to locomotive wheels. At the time of Matthias Baldwin's death, the Baldwin Locomotive Works had built some 1,500 locomotives: it went on to become the largest locomotive building firm to develop from a single foundation, and by the time it built its last steam locomotive, in 1955, had produced about 75,000 in total.

Further Reading

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1880, New York: Dover Publications Inc.

J.Marshall, 1978, *A Biographical Dictionary of Railway Engineers*, Newton Abbot:

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Dictionary of American Biography.

PJGR

Banu Musa ibn Shakir

fl. c.850

Arab astronomers and engineers.

The Banu were the three sons of Musa ibn Shakir. His origins were unpromising, for he was a robber, but the caliph al-Ma'mun, a great patron of science and learning, took the sons into his academy and had them educated. The eldest and most prominent, Muhammed, took up the study of geometry, logic and astronomy, while another, al-Hasan, also studied geometry. The third, Ahmad, turned to mechanics. Together, the Banu established a group for the translation of texts from antiquity, especially Greece, on science and mechanics. They were responsible for compiling the *Kitab al-Hiyal (Book of Ingenious Devices)*, the first of two major works on mechanics that appeared in the medieval Islamic world. The authors drew freely from earlier Greek writers, particularly **Hero** and Philon. The work is a technical manual for making devices such as lamps, pipes in spring wells and drinking vessels, most depending on differences in air pressure generated by the movement of liquids. These principles were applied to make a self-filling oil lamp. The work also demonstrated the lifting of heavy weights by means of pulleys. In another work, the *Qarastun (Book of the Balance)*, the Banu showed how different weights could be balanced by varying the distance from the fulcrum.

Further Reading

Dictionary of Scientific Biography.

LRD

Barber, John

baptized 22 October 1734 Greasley, Nottinghamshire, England

d. 6 November 1801 Attleborough, Nuneaton, England

English inventor of the gas turbine and jet propulsion.

He was the son of Francis Barber, coalmaster of Greasley, and Elizabeth Fletcher. In his will of 1765, his uncle, John Fletcher, left the bulk of his property, including collieries and Stainsby House, Horsley Woodhouse, Derbyshire, to John Barber. Another uncle, Robert, bequeathed him property in the next village, Smalley. It is clear that at this time John Barber was a man of considerable means. On a tablet erected by John in 1767, he acknowledges his debt to his uncle John in the words 'in remembrance of the man who trained him up from a youth'. At this time John Barber was living at Stainsby House and had already been granted his first patent, in 1766. The contents of this patent, which included a reversible water turbine, and his subsequent patents, suggest that he was very familiar with mining equipment, including the **Newcomen** engine. It comes as rather a surprise that c.1784 he became bankrupt and had to leave Stainsby House, evidently moving to Attleborough. In a strange twist, a descendent of Mr Sitwell, the new owner, bought the prototype Akroyd **Stuart** oil engine from the Doncaster Show in 1891.

The second and fifth (final) patents, in 1773 and 1792, were concerned with smelting and the third, in 1776, featured a boiler-mounted impulse steam turbine. The fourth and most important patent, in 1791, describes an engine that could be applied to the 'grinding of corn, flints, etc.', 'rolling, slitting, forging or battering iron and other metals', 'turning of mills for spinning', 'turning up coals and other minerals from mines', and 'stamping of ores, raising water'. Further, and importantly, the directing of the fluid stream into smelting furnaces or at the stern of ships to propel them is mentioned. The engine described comprised two retorts for heating coal or oil to produce an inflammable gas, one to operate while the other was cleansed and recharged. The resultant gas, together with the right amount of air, passed to a beam-operated pump and a water-cooled combustion chamber, and then to a water-cooled nozzle to an impulse gas turbine, which drove the pumps and provided the output. A clear description of the thermodynamic sequence known as the Joule Cycle (Brayton in the USA) is thus given. Further, the method of gas production predates **Murdoch's** lighting of the Soho foundry by gas.

It seems unlikely that John Barber was able to get his engine to work; indeed, it was well over a hundred years before a continuous combustion chamber was achieved. However, the details of the specification, for example the use of cooling water jackets and injection, suggest that considerable experimentation had taken place.

To be active in the taking out of patents over a period of 26 years is remarkable; that the best came after bankruptcy is more so. There is nothing to suggest that the cost of his experiments was the cause of his financial troubles.

Further Reading

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C.Lyle Cummins, 1976, *Internal Fire*, Carnot Press.

Barclay, Robert

b. c.1833

d. November 1876

English inventor of the offset method in printing.

Barclay, a member of the celebrated banking family, ran a printing business in the City of London in partnership with John Doyle Fry, of the (also famous) chocolate-making family. In 1875 Barclay took out two patents, the first bearing Fry's name as well, for printing on to tinplate by way of the offset principle. He recognized that transferring or 'offsetting' the print on to an impression cylinder of a yielding material would give the best results. The cylinder would be covered with glazed or varnished cardboard, rather than the rubber that was later to be used.

Barclay disposed of his patents to Bryant and May, the match manufacturers, for printing decorative metal matchbox covers. It was recognized that the method had applications in other industries, and eventually the principle was applied in the currently most widely used method of printing, offset lithography.

Further Reading

Journal of Printing History 8(1972):60; 9 (1973):4 (brief details of Barclay's life).

LRD

Bardeen, John

b. 23 May 1908 Madison, Wisconsin, USA

d. 30 January 1991 Boston, Massachusetts, USA

American physicist, the first to win the Nobel Prize for Physics twice.

Born the son of a professor of anatomy, he studied electrical engineering at the University of Wisconsin. He then worked for three years as a geophysicist at the Gulf Research Laboratories before taking a PhD in mathematical physics at Princeton, where he was a graduate student. For some time he held appointments at the University of Minnesota and at Harvard, and during the Second World War he joined the US Naval Ordnance Laboratory. In 1945 he joined the Bell Telephone Laboratories to head a new department to work on solid-state devices. While there, he and W.H. **Brattain** in 1948

published a paper that introduced the transistor. For this he, Brattain and **Shockley** won the Nobel Prize for Physics in 1956. In 1951 he moved to the University of Illinois as Professor of Physics and Electrical Engineering. There he worked on superconductivity, a phenomenon described in 1911 by Kamerling-Onnes. Bardeen worked with L.N. Cooper and J.A.Schrieffer, and in 1972 they were awarded the Nobel Prize for Physics for the 'BCS Theory', which suggested that, under certain circumstances at very low temperatures, electrons can form bound pairs.

Principal Honours and Distinctions

Nobel Prize for Physics (jointly with Brattain and Shockley) 1956, (jointly with Cooper and Schrieffer) 1972.

Further Reading

A.Isaacs and E.Martin (eds), 1985, *Longmans Dictionary of 20th Century Biography* .

IMcN

Barlow, Edward

baptized 15 December 1636 near Warrington, Cheshire, England
d. 1716

English priest and mechanic who invented rack striking, repeating mechanisms for clocks and watches and, with others, patented a horizontal escapement for watches.

Barlow was the son of Edward Booth, but he adopted the surname of his godfather, the Benedictine monk Ambrose Barlow, as a condition of his will. In 1659 he entered the English College at Lisbon, and after being ordained a priest he was sent to the English mission. There he resided at Parkhall in Lancashire, the seat of Mr Houghton, with whom he later collaborated on the horizontal escapement.

At a time when it was difficult to produce a light to examine the dial of a clock or watch at night, a mechanism that would indicate the hours and subdivisions of the hour audibly and at will was highly desirable. The count wheel, which had been used from the earliest times to control the striking of a clock, was unsuitable for this purpose as it struck the hours in sequence. If the mechanism was set off manually to determine the time, the strike would no longer correspond with the indications on the dial. In 1675 Barlow invented rack striking, where the hour struck was determined solely by the position of the hour hand. With this mechanism it was therefore possible to repeat the hour at will, without upsetting the sequence of striking. In 1687 Barlow tried to patent a method of

repeating for watches, but it was rejected by James II in favour of a system produced by the watchmaker Daniel Quare and which was simpler to operate. He was successful in obtaining a patent for a horizontal escapement for watches in 1695, in collaboration with William Houghton and Thomas **Tompion**. Although this escapement was little used, it can be regarded as the forerunner of the cylinder escapement that George **Graham** introduced c. 1725.

Bibliography

1695 (with William Houghton and Thomas Tompion), British patent no. 344 (a horizontal escapement).

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Dictionary of National Biography, 1885, Vol. 1, Oxford, S.V. Barlow.

Britten's Old Clocks & Watches and Their Makers, 1982, rev. Cecil Clutton, 9th edn, London, pp. 148, 310, 313 (provides a technical description of rack striking, repeating work and the horizontal escapement).

DV

Barlow, Peter

b. 13 October 1776 Norwich, England

d. 1 March 1862 Kent, England

English mathematician, physicist and optician.

Barlow had little formal academic education, but by his own efforts rectified this deficiency. His contributions to various periodicals ensured that he became recognized as a man of considerable scientific understanding. In 1801, through competitive examination, he became Assistant Mathematics Master at the Royal Military Academy, Woolwich, and some years later was promoted to Professor. He resigned from this post in 1847, but retained full salary in recognition of his many public services.

He is remembered for several notable achievements, and for some experiments designed to overcome problems such as the deviation of compasses in iron ships. Here, he proposed the use of small iron plates designed to overcome other attractions: these were used by both the British and Russian navies. Optical experiments commenced around 1827 and in later years he carried out tests to optimize the size and shape of many parts used in the railways that were spreading throughout Britain and elsewhere at that time.

In 1814 he published mathematical tables of squares, cubes, square roots, cube roots and reciprocals of all integers from 1 to 10,000. This volume was of great value in ship

design and other engineering processes where heavy numerical effort is required; it was reprinted many times, the last being in 1965 when it had been all but superseded by the calculator and the computer. In the preface to the original edition, Barlow wrote, ‘the only motive which prompted me to engage in this unprofitable task was the utility that I conceived might result from my labour... if I have succeeded in facilitating abstruse arithmetical calculations, then I have obtained the object in view.’

Principal Honours and Distinctions

FRS 1823; Copley Medal (for discoveries in magnetism) 1825. Honorary Member, Institution of Civil Engineers 1820.

Bibliography

1811, *An Elementary Investigation of the Theory of Numbers* .

1814, *Barlow's Tables* (these have continued to be published until recently, one edition being in 1965 (London: Spon); later editions have taken the integers up to 12,500).

1817, *Essay on the Strength of Timber and Other Materials* .

Further Reading

Dictionary of National Biography .

FMW

Barnaby, Kenneth C.

b. c.1887 England

d. 22 March 1968 England

English naval architect and technical author.

Kenneth Barnaby was an eminent naval architect, as were his father and grandfather before him: his grandfather was Sir Nathaniel Barnaby KGB, Director of Naval Construction, and his father was Sydney W. Barnaby, naval architect of John I. Thornycroft & Co., Shipbuilders, Southampton. At one time all three were members of the Institution of Naval Architects, the first time that this had ever occurred with three members from one family.

Kenneth Barnaby served his apprenticeship at the Thornycroft shipyard in Southampton and later graduated in engineering from the Central Technical College, South Kensington, London. He worked for some years at Le Havre and at John Brown's shipyard at Clydebank before rejoining his old firm in 1916 as Assistant to the Shipyard

Manager. In 1919 he went to Rio de Janeiro as a chief ship draughtsman, and finally he returned to Thornycroft, in 1924 he succeeded his father as Naval Architect, and remained in that post until his retirement in 1955, having been appointed a director in 1950.

Barnaby had a wide knowledge and understanding of ships and ship design and during the Second World War he was responsible for much of the development work for landing craft, as well as for many other specialist ships built at the Southampton yard. His experience as a deep-sea yachtsman assisted him. He wrote several important books; however, none can compare with the *Centenary Volume* of the Royal Institution of Naval Architects. In this work, which is used and read widely to this day by naval architects worldwide, he reviewed every paper presented and almost every verbal contribution made to the *Transactions* during its one hundred years.

Principal Honours and Distinctions

OBE 1945. Associate of the City and Guilds Institute. Royal Institution of Naval Architects Froude Gold Medal 1962. Honorary Vice-President, Royal Institution of Naval Architects 1960–8.

Bibliography

c.1900, *Marine Propellers*, London.

1949, *Basic Naval Architecture*, London.

1960, *The Institution of Naval Architects 1860–1960*, London.

1964, *100 Years of Specialised Shipbuilding and Engineering*, London.

1968, *Some Ship Disasters and their Causes*, London.

FMW

Barnack, Oskar

b. 1879 Berlin, Germany

d. January 1936 Wetzlar, Germany

German camera designer who conceived the first Leica camera and many subsequent models.

Oskar Barnack was an optical engineer, introspective and in poor health, when in 1910 he was invited through the good offices of his friend the mechanical engineer Emil Mechau, who worked for Ernst Leitz, to join the company at Wetzlar to work on research into microscope design. He was engaged after a week's trial, and on 2 January 1911 he was put in charge of microscope research. He was an enthusiastic photographer, but excursions with his large and heavy plate camera equipment taxed his strength. In 1912,

Mechau was working on a revolutionary film projector design and needed film to test it. Barnack suggested that it was not necessary to buy an expensive commercial machine—why not make one? Leitz agreed, and Barnack constructed a 35 mm movie camera, which he used to cover events in and around Wetzlar.

The exposure problems he encountered with the variable sensitivity of the cine film led him to consider the design of a still camera in which short lengths of film could be tested before shooting—a kind of exposure-meter camera. Dissatisfied with the poor picture quality of his first model, which took the standard cine frame of 18×24 mm, he built a new model in which the frame size was doubled to 36×24 mm. It used a simple focal-plane shutter adjustable to 1/500 of a second, and a **Zeiss** Milar lens of 42 mm focal length. This is what is now known as the UR-Leica. Using his new camera, 1/250 of the weight of his plate equipment, Barnack made many photographs around Wetzlar, giving postcard-sized prints of good quality.

Ernst Leitz Junior was lent the camera for his trip in June 1914 to America, where he was urged to put it into production. Visiting George **Eastman** in Rochester, Leitz passed on Barnack's requests for film of finer grain and better quality. The First World War put an end to the chances of developing the design at that time. As Germany emerged from the postwar chaos, Leitz Junior, then in charge of the firm, took Barnack off microscope work to design prototypes for a commercial model. Leitz's Chief Optician, Max Berek, designed a new lens, the f3.5 Elmax, for the new camera. They settled on the name Leica, and the first production models went on show at the Leipzig Spring Fair in 1925. By the end of the year, 1,000 cameras had been shipped, despite costing about two months' good wages.

The Leica camera established 35 mm still photography as a practical proposition, and film manufacturers began to create the special fine-grain films that Barnack had longed for. He continued to improve the design, and a succession of new Leica models appeared with new features, such as interchangeable lenses, coupled range-finders, 250 exposures. By the time of his sudden death in 1936, Barnack's life's work had forever transformed the nature of photography.

Further Reading

J.Borgé and G.Borgé, 1977, *Prestige de la photographie* .

BC

Barnett, James Rennie

b. 6 September 1864 Johnstone, Renfrewshire, Scotland

d. 13 January 1965 Glasgow, Scotland

Scottish naval architect described as one of the 'Fathers of the Modern Lifeboat Fleet'.

Barnett studied naval architecture at the University of Glasgow and served an apprenticeship under the yacht designer George L. **Watson**. This was unusual as most undergraduates tended, then as now, to spend their initial years in the various departments of a shipyard, with concentration on the work of the drawing office. In 1904 Barnett succeeded Watson as Principal of the firm, and was simultaneously appointed Consulting Naval Architect to the Royal National Lifeboat Institution (RNLI), a post he held until his retirement in 1947. During this period many changes in lifeboat design brought increasing efficiency, better ranges of stability and improvements in operational safety. The RNLI recognized the great service of Barnett and his predecessor by naming two lifeboat types after them: the *Watson* and the *Barnett*.

Principal Honours and Distinctions

OBE 1918. Royal National Lifeboat Institution Gold Medal.

Bibliography

Barnett was a member of both the Institution of Naval Architects and the Institution of Engineers and Shipbuilders in Scotland. Between 1900 and 1931 he presented a total of six papers to these institutions, on steam yachts, sailing yachts, motor yachts and on lifeboat design.

FMW

Barry, Sir Charles

b. 23 May 1795 Westminster, London, England

d. 12 May 1860 Clapham, London, England

English architect who was a leader in the field between the years 1830 and 1860.

Barry was typical of the outstanding architects of this time. His work was eclectic, and he suited the style—whether Gothic or classical—to the commission and utilized the then-traditional materials and methods of construction. He is best known as architect of the new Palace of Westminster; he won the competition to rebuild it after the disastrous fire of the old palace in 1834. Bearing this in mind in the rebuilding, Barry utilized that characteristic nineteenth-century material, iron for joists and roofing plates.

Principal Honours and Distinctions

Knighthood 1852. Member of the Royal Academy; the Royal Society; the Academies of St Luke, Rome; St Petersburg (and others); and the American Institute of Architects. RIBA Gold Medal 1850.

Further Reading

Marcus Whiffen, *The Architecture of Sir Charles Barry in Manchester and Neighbourhood*, Royal Manchester Institution.

H.M.Port (ed.), 1976, *The Houses of Parliament*, Yale University Press.

H.M.Colvin (ed.), *The History of the King's Works*, Vol. 6, HMSO.

DY

Barsanti, Eugenio

b. 1821 Italy

d. 1864 Liège, Belgium

Italian co-inventor of the internal combustion engine; lecturer in mechanics and hydraulics.

A trained scientist and engineer, Barsanti became acquainted with a distinguished engineer, Felice **Matteucci**, in 1851. Their combined talents enabled them to produce a number of so-called free-piston atmospheric engines from 1854 onwards. Using a principle demonstrated by the Swiss engineer Isaac de Rivaz in 1827, the troublesome explosive shocks encountered by other pioneers were avoided. A piston attached to a long toothed rack was propelled from beneath by the expansion of burning gas and allowed unrestricted movement. A resulting partial vacuum enabled atmospheric pressure to return the piston and produce the working stroke. Electric ignition was a feature of all the Italian engines.

With many successful applications, a company was formed in 1860. A 20 hp (15 kW) engine stimulated much interest. Attempts by John Cockerill of Belgium to mass-produce small power units of up to 4 hp (3 kW) came to an abrupt end; during the negotiations Barsanti contracted typhoid fever and later died. The project was abandoned, but the working principle of the Italian engine was used successfully in the Otto-Langen engine of 1867.

Bibliography

13 May 1854, British Provisional Patent no. 1,072 (the Barsanti and Matteucci engine).

12 June 1857, British patent no. 1,655 (contained many notable improvements to the design).

Further Reading

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Vincenzo Vannacci, 1955, *L'invenzione del motore a scoppio realizzata dai toscani Barsanti e Matteucci 1854–1954*, Florence.

See also **Langen, Eugen ; Otto, Niklaus August** .

KAB

Bateman, John Frederic La Trobe

b. 30 May 1810 Lower Wyke, near Halifax, Yorkshire, England

d. 10 June 1889 Moor Park, Farnham, Surrey, England

English civil engineer whose principal works were concerned with reservoirs, water-supply schemes and pipelines.

Bateman's maternal grandfather was a Moravian missionary, and from the age of 7 he was educated at the Moravian schools at Fairfield and Ockbrook. At the age of 15 he was apprenticed to a 'civil engineer, land surveyor and agent' in Oldham. After his apprenticeship, Bateman commenced his own practice in 1833. One of his early schemes and reports was in regard to the flooding of the river Medlock in the Manchester area. He came to the attention of William **Fairbairn**, the engine builder and millwright of Canal Street, Ancoats, Manchester. Fairbairn used Bateman as his site surveyor and as such he prepared much of the groundwork for the Bann reservoirs in Northern Ireland. Whilst the reports on the proposals were in the name of Fairbairn, Bateman was, in fact, appointed by the company as their engineer for the execution of the works. One scheme of Bateman's which was carried forward was the Kendal Reservoirs. The Act for these was signed in 1845 and was implemented not for the purpose of water supply but for the conservation of water to supply power to the many mills which stood on the river Kent between Kentmere and Morecambe Bay. The Kentmere Head dam is the only one of the five proposed for the scheme to survive, although not all the others were built as they would have retained only small volumes of water.

Perhaps the greatest monument to the work of J.F. La Trobe Bateman is Manchester's water supply; he was consulted about this in 1844, and construction began four years later. He first built reservoirs in the Longdendale valley, which has a very complicated geological stratification. Bateman favoured earth embankment dams and gravity feed rather than pumping; the five reservoirs in the valley that impound the river Etherow were complex, cored earth dams. However, when completed they were greatly at risk from landslips and ground movement. Later dams were inserted by Bateman to prevent

water loss should the older dams fail. The scheme was not completed until 1877, by which time Manchester's population had exceeded the capacity of the original scheme; Thirlmere in Cumbria was chosen by Manchester Corporation as the site of the first of the Lake District water-supply schemes. Bateman, as Consulting Engineer, designed the great stone-faced dam at the west end of the lake, the 'gothic' straining well in the middle of the east shore of the lake, and the 100-mile (160 km) pipeline to Manchester. The Act for the Thirlmere reservoir was signed in 1879 and, whilst Bateman continued as Consulting Engineer, the work was supervised by G.H. Hill and was completed in 1894.

Bateman was also consulted by the authorities in Glasgow, with the result that he constructed an impressive water-supply scheme derived from Loch Katrine during the years 1856–60. It was claimed that the scheme bore comparison with 'the most extensive aqueducts in the world, not excluding those of ancient Rome'. Bateman went on to superintend the waterworks of many cities, mainly in the north of England but also in Dublin and Belfast. In 1865 he published a pamphlet, *On the Supply of Water to London from the Sources of the River Severn*, based on a survey funded from his own pocket; a Royal Commission examined various schemes but favoured Bateman's.

Bateman was also responsible for harbour and dock works, notably on the rivers Clyde and Shannon, and also for a number of important water-supply works on the Continent of Europe and beyond. Dams and the associated reservoirs were the principal work of J.F. La Trobe Bateman; he completed forty-three such schemes during his professional career. He also prepared many studies of water-supply schemes, and appeared as professional witness before the appropriate Parliamentary Committees.

Principal Honours and Distinctions

FRS 1860. President, Institution of Civil Engineers 1878, 1879.

Bibliography

Among his publications *History and Description of the Manchester Waterworks*, (1884, London), and *The Present State of Our Knowledge on the Supply of Water to Towns*, (1855, London: British Association for the Advancement of Science) are notable.

Further Reading

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Obituary, 1889, *Proceedings of the Royal Society* 46:xliv–xlvi.

G.M. Binnie, 1981, *Early Victorian Water Engineers*, London.

P.N. Wilson, 1973, 'Kendal reservoirs', *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society* 73.

Baudot, Jean-Maurice-Emile

b. 11 September 1845 Magneux, France

d. 28 March 1903 Sceaux, France

French engineer who developed the multiplexed telegraph and devised a 5-bit code for data communication and control.

Baudot had no formal education beyond his local primary school and began his working life as a farmer, as was his father. However, in September 1869 he joined the French telegraph service and was soon sent on a course on the recently developed Hughes printing telegraph. After service in the Franco-Prussian war as a lieutenant with the military telegraph, he returned to his civilian duties in Paris in 1872. He was there encouraged to develop (in his own time!) a multiple Hughes system for time-multiplexing of several telegraph messages. By using synchronized clockwork-driven rotating switches at the transmitter and receiver he was able to transmit five messages simultaneously; the system was officially adopted by the French Post & Telegraph Administration five years later. In 1874 he patented the idea of a 5-bit (i.e. 32-permutation) code, with equal on and off intervals, for telegraph transmission of the Roman alphabet and punctuation signs and for control of the typewriter-like teleprinter used to display the message. This code, known as the Baudot code, was found to be more economical than the existing **Morse** code and was widely adopted for national and international telegraphy in the twentieth century. In the 1970s it was superseded by 7—and 8-bit codes.

Further development of his ideas on multiplexing led in 1894 to methods suitable for high-speed telegraphy. To commemorate his contribution to efficient telegraphy, the unit of signalling speed (i.e. the number of elements transmitted per second) is known as the baud.

Bibliography

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Further Reading

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P.Lajarrige, 1982, 'Chroniques téléphoniques et télégraphiques', *Collection historique des télécommunications*.

Bauer, Georg

See **Agricola, Georgius** .

Bauer, H.

fl. c.1885

German (?) inventor of a press-stud fastener.

Fastenings are an essential component of the majority of garments. Great advances were made in Germany with press studs in the late nineteenth century after the original invention by Louis **Hannart** in 1863. In 1885, Bauer patented a spring and stud fastener.

Further Reading

I.McNeil (ed.), 1990, *An Encyclopaedia of the History of Technology* , London: Routledge, pp. 852–3 (provides an account of the development of fastenings).

RLH

Baumann, Karl

b. 18 April 1884 Switzerland

d. 14 July 1971 Ilkley, Yorkshire

Swiss/British mechanical engineer, designer and developer of steam and gas turbine plant.

After leaving school in 1902, he went to the Ecole Polytechnique, Zurich, leaving in 1906 with an engineering diploma. He then spent a year with Professor A.Stodola, working on steam engines, turbines and internal combustion engines. He also conducted research in the strength of materials. After this, he spent two years as Research and Design Engineer at the Nuremberg works of Maschinenfabrik Augsburg-Nürnberg. He came to England in 1909 to join the British Westinghouse Co. Ltd in Manchester, and by 1912 was Chief Engineer of the Engine Department of that firm. The firm later became the Metropolitan-

Vickers Electrical Co. Ltd (MV), and Baumann rose from Chief Mechanical Engineer through to, by 1929, Special Director and Member of the Executive Management Board; he remained a director until his retirement in 1949.

For much of his career, Baumann was in the forefront of power station steam-cycle development, pioneering increased turbine entry pressures and temperatures, in 1916 introducing multi-stage regenerative feed-water heating and the Baumann turbine multi-exhaust. His 105 MW set for Battersea 'A' station (1933) was for many years the largest single-axis unit in Europe. From 1938 on, he and his team were responsible for the first axial-flow aircraft propulsion gas turbines to fly in England, and jet engines in the 1990s owe much to the 'Beryl' and 'Sapphire' engines produced by MV. In particular, the design of the compressor for the Sapphire engine later became the basis for Rolls-Royce units, after an exchange of information between that company and Armstrong-Siddeley, who had previously taken over the aircraft engine work of MV. Further, the Beryl engine formed the basis of 'Gatric', the first marine gas turbine propulsion engine.

Baumann was elected to full membership for the Institution of Mechanical Engineers in 1929 and a year later was awarded the Thomas Hawksley Gold Medal by that body, followed by their James Clayton Prize in 1948: in the same year he became the thirty-fifth Thomas Hawksley lecturer. Many of his ideas and introductions have stood the test of time, being based on his deep and wide understanding of fundamentals.

JB

Baxter, George

b. 31 July 1804 Lewes, Sussex, England

d. 11 January 1867 Sydenham, London, England

English pioneer in colour printing.

The son of a printer, Baxter was apprenticed to a wood engraver and there began his search for improved methods of making coloured prints, hitherto the perquisite of the rich, in order to bring them within reach of a wider public. After marriage to the daughter of Robert Harrild, founder of the printing firm of Harrild & Co., he set up house in London, where he continued his experiments on colour while maintaining the run-of-the-mill work that kept the family.

The nineteenth century saw a tremendous advance in methods of printing pictures, produced as separate prints or as book illustrations. For the first three decades colour was supplied by hand, but from the 1830s attempts were made to print in colour, using a separate plate for each one. Coloured prints were produced by chromolithography and relief printing on a small scale. Prints were first made with the latter method on a commercial scale by Baxter with a process that he patented in 1835. He generally used a key plate that was engraved, aquatinted or lithographed; the colours were then printed separately from wood or metal blocks. Baxter was a skilful printer and his work reached a

high standard. An early example is the frontispiece to Robert Mudie's *Summer* (1837). In 1849 he began licensing his patent to other printers, and after the Great Exhibition of 1851 colour relief printing came into its own. Of the plethora of illustrated literature that appeared then, Baxter's *Gems of the Great Exhibition* was one of the most widely circulated souvenirs of the event.

Baxter remained an active printer through the 1850s, but increasing competition from the German coloured lithographic process undermined his business and in 1860 he gave up the unequal struggle. In May of that year, all his oil pictures, engravings and blocks went up for auction, some 3,000 lots altogether. Baxter retired to Sydenham, then a country place, making occasional visits to London until injuries sustained in a mishap while he was ascending a London omnibus led to his death. Above all, he helped to initiate the change from the black and white world of pre-Victorian literature to the riotously colourful world of today.

Further Reading

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M.E.Mitzmann, 1978, *George Baxter and the Baxter Prints*, Newton Abbot: David & Charles.

LRD

Bayard, Hippolyte

b. 1801 Breteuil-sur-Noye, France
d. 1887

French photographer, inventor of an early direct positive paper process.

Educated as a notary's clerk, Bayard began his working life in Paris in the Ministry of Finance. His interest in art led him to investigations into the chemical action of light, and he began his experiments in 1837. In May 1839 Bayard described an original photographic process which produced direct positive images on paper. It was devised independently of **Talbot** and before details of **Daguerre's** process had been published. During the same period, similar techniques were announced by other investigators and Bayard became involved in a series of priority disputes. Bayard's photographs were well received when first exhibited, and examples survive to the present day. Because the process required long exposure times it was rarely practised, but Bayard is generally credited with being an independent inventor of photography.

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Further Reading

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JW

Beau de Rochas, Alphonse Eugène

b. 1815 France

d. 1893 France

French railway engineer, patentee of a four-stroke cycle engine.

Renowned more for his ideas on technical matters than his practical deeds, Beau de Rochas was a prolific thinker. Within a few years he proposed a rail tunnel beneath the English Channel, a submarine telegraph, a new kind of drive for canal boats, the use of steel for high-pressure boilers and a method of improving the adhesion of locomotive wheels travelling the Alps.

The most notable of Beau de Rochas's ideas occurred in 1862 when he was employed as Ingenieur Attaché to the Central de Chemins. With remarkable foresight, he expressed the theoretical considerations for the cycle of operations for the now widely used four-stroke cycle engine. A French patent of 1862 lapsed with a failure to pay the annuity and thus the proposals for a new motive power lapsed into obscurity. Resurrected some twenty years later, the Beau de Rochas tract figures prominently in patent litigation cases. In 1885, a German court upheld a submission by a German patent lawyer that **Otto's** four-stroke engine of 1876 infringed the Beau de Rochas patent. It remains a mystery why Beau de Rochas never emerged at any time to defend his claims. In France he is regarded as the inventor of the four-stroke cycle engine.

Principal Honours and Distinctions

Société d'Encouragement pour l'Industrie Nationale, prize of 3000 francs, 1891.

Bibliography

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Further Reading

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B.Donkin, 1900, *The Gas, Oil and Air Engine*, London: p. 467.

See also **Langen, Eugen**.

KAB

Beaumont, Huntingdon

b. c.1560 Coleorton (?), Leicestershire, England

d. 1624 Nottingham, England

English speculator in coal-mining, constructor of the first surface railway in Britain.

Huntingdon Beaumont was a younger son of a landed family whose estates included coal-mines at Coleorton and Bedworth. From these, no doubt, originated his great expertise in coal-mining and mine management. His subsequent story is a complex one of speculation in coal mines: agreements, partnerships, and debts, and, in trying to extricate himself from the last, attempts to improve profitability, and ever-greater enterprises. He leased mines in 1601 at Wollaton, near Nottingham, and in 1603 at Strelley, which adjoins Wollaton but is further from Nottingham, where lay the market for coal. To reduce the transport cost of Strelley coal, Beaumont laid a wooden wagonway for two miles or so to Wollaton Lane End, the point at which the coal was customarily sold. In earlier times wooden railways had probably been used in mines, following practice on the European continent, but Beaumont's was the first on the surface in Britain. The market for coal in Nottingham being limited, Beaumont, with partners, attempted to send coal to London by water, but the difficult navigation of the Trent at this period made the venture uneconomic. With a view still to supplying London, c.1605 they took leases of mines near Blyth, north of Newcastle upon Tyne. Here too Beaumont built wagonways, to convey coal to the coast, but despite considerable expenditure the mines could not be made economic and Beaumont returned to Strelley. Although he worked the mine night and day, he was unable to meet the demands of his creditors, who eventually had him imprisoned for debt. He died in gaol.

Further Reading

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discussing Beaumont and his wagonways).

PJGR

Beckett, Sir Edmund

See **Grimthorpe (of Grimthorpe), Edmund Beckett, Baron.**

Bedson, George

b. 3 November 1820 Sutton Coldfield, Warwickshire, England

d. 12 December 1884 Manchester (?), England

English metallurgist, inventor of the continuous rolling mill.

He acquired a considerable knowledge of wire-making in his father's works before he took a position in 1839 at the works of James Edleston at Warrington. From there, in 1851, he went to Manchester as Manager of Richard Johnson & Sons' wire mill, where he remained for the rest of his life. It was there that he initiated several important improvements in the manufacture of wire. These included a system of circulating puddling furnace water bottoms and sides, and a galvanizing process. His most important innovation, however, was the continuous mill for producing iron rod for wiredrawing. Previously the red-hot iron billets had to be handled repeatedly through a stand or set of rolls to reduce the billet to the required shape, with time and heat being lost at each handling. In Bedson's continuous mill, the billet entered the first of a succession of stands placed as closely to each other as possible and emerged from the final one as rod suitable for wiredrawing, without any intermediate handling. A second novel feature was that alternate rolls were arranged vertically to save turning the piece manually through a right angle. That improved the quality as well as the speed of production. Bedson's first continuous mill was erected in Manchester in 1862 and had sixteen stands in tandem. A mill on this principle had been patented the previous year by Charles While of Pontypridd, South Wales, but it was Bedson who made it work and brought it into use commercially. A difficult problem to overcome was that as the piece being rolled lengthened, its speed increased, so that each pair of rolls had to increase correspondingly. The only source of power was a steam engine working a single drive shaft, but Bedson achieved the greater speeds by using successively larger gear-wheels at each stand.

Bedson's first mill was highly successful, and a second one was erected at the Manchester works; however, its application was limited to the production of small bars, rods and sections. Nevertheless, Bedson's mill established an important principle of

rolling-mill design that was to have wider applications in later years.

Further Reading

Obituary, 1884, *Journal of the Iron and Steel Institute* 27:539–40.
W.K.V.Gale, 1969, *Iron and Steel*, London: Longmans, pp. 81–2.

LRD

Behr, Fritz Bernhard

b. 9 October 1842 Berlin, Germany
d. 25 February 1927

German (naturalized British in 1876) engineer, promoter of the Lartigue monorail system.

Behr trained as an engineer in Britain and had several railway engineering appointments before becoming associated with C.F.M.-T. **Lartigue** in promoting the Lartigue monorail system in the British Isles. In Lartigue's system, a single rail was supported on trestles; vehicles ran on the rail, their bodies suspended pannier-fashion, stabilized by horizontal rollers running against light guide rails fixed to the sides of the trestles. Behr became Managing Director of the Listowel & Ballyunion Railway Company, which in 1888 opened its Lartigue system line between those two places in the south-west of Ireland. Three locomotives designed by J.T.A. **Mallet** were built for the line by Hunslet Engine Company, each with two horizontal boilers, one either side of the track. Coaches and wagons likewise were in two parts. Technically the railway was successful, but lack of traffic caused the company to go bankrupt in 1897: the railway continued to operate until 1924.

Meanwhile Behr had been thinking in terms far more ambitious than a country branch line. Railway speeds of 150mph (240km/h) or more then lay far in the future: engineers were uncertain whether normal railway vehicles would even be stable at such speeds. Behr was convinced that a high-speed electric vehicle on a substantial Lartigue monorail track would be stable. In 1897 he demonstrated such a vehicle on a 3mile (4.8km) test track at the Brussels International Exhibition. By keeping the weight of the motors low, he was able to place the seats above rail level. Although the generating station provided by the Exhibition authorities never operated at full power, speeds over 75mph (120 km/h) were achieved.

Behr then promoted the Manchester-Liverpool Express Railway, on which monorail trains of this type running at speeds up to 110mph (177km/h) were to link the two cities in twenty minutes. Despite strong opposition from established railway companies, an Act of Parliament authorizing it was made in 1901. The Act also contained provision for the Board of Trade to require experiments to prove the system's safety. In practice this meant

that seven miles of line, and a complete generating station to enable trains to travel at full speed, must be built before it was known whether the Board would give its approval for the railway or not. Such a condition was too severe for the scheme to attract investors and it remained stillborn.

Further Reading

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See also **Brennan, Louis**.

PJGR

Behrens, Peter

b. 14 April 1868 Hamburg, Germany

d. 27 February 1940 Berlin, Germany

German pioneer of modern architecture, developer of the combined use of steel, glass and concrete in industrial work.

During the 1890s Behrens, as an artist, was a member of the German branch of *Sezessionismus* and then moved towards *Jugendstil* (Art Nouveau) types of design in different media. His interest in architecture was aroused during the first years of the twentieth century, and a turning-point in his career was his appointment in 1907 as Artistic Supervisor and Consultant to AEG, the great Berlin electrical firm. His Turbine Factory (1909) in the city was a breakthrough in design and is still standing: in steel and glass, with visible girder construction, this is a truly functional modern building far ahead of its time. In 1910 two more of Behrens's factories were completed in Berlin, followed in 1913 by the great AEG plant at Riga, Latvia.

After the First World War Behrens was in great demand for industrial construction. He designed office schemes such as those at the Mannesmann Steel Works in Dusseldorf (1911–12; now destroyed) and, in a departure from his earlier work, was responsible for a more Expressionist form of design, mainly in brick, in his extensive complex for I.G.Farben at Höchst (1920–4).

In the years before the First World War, some of those who were later amongst the most famous names in modern architecture were among his pupils: **Gropius**, **Mies van der Rohe** and Le Corbusier (Charles-Edouard **Jeanneret**).

Further Reading

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W. Weber (ed.), 1966, *Peter Behrens (1868–1940)*, Kaiserslautern, Germany: Pfalzgalerie.

DY

Belidor, Bernard Forest de

- b. 1698 Catalonia, Spain
d. 8 September 1761 Paris, France

French engineer and founder of the science of modern ballistics.

Belidor was the son of a French army officer, who died when he was six months old, and was thereafter brought up by a brother officer. He soon demonstrated a scientific bent, and gravitated to Paris, where he became involved in the determination of the Paris meridian. He was then appointed Professor at the artillery school at La Fère, where he began to pursue the science of ballistics in earnest. He was able to disprove the popular theory that range was directly proportional to the powder charge, and also argued that the explosive power of a charge was greatest at the end of the explosion; he advocated spherical chambers in order to take advantage of this. His ideas made him unpopular with the 'establishment', especially the Master of the King's artillery, and he was forced to leave France for a time, becoming a consultant to authorities in Bohemia and Bavaria. However, he was reinstated, and in 1758 he was appointed Royal Inspector of Artillery, a post that he held until his death.

Belidor also made a name for himself in hydraulics and influenced design in this field for more than a century after his death. In addition, he was the first to make practical application of integral calculus.

Bibliography

- Belidor was the author of several books, of which the most significant were:
1739, *La Science des ingénieurs*, Paris (reprinted several times, the last edition being as late as 1830).
1731, *Le Bombardier françois*, Paris: L'Imprimerie royale.
1737, *Architecture hydraulique*, 2 vols, Paris.

Further Reading

- R.S.Kirby and P.G.Laurson, 1932, *The Early History of Modern Civil Engineering*, New Haven: Yale University Press (describes his work in the field of hydraulics).
 D.Chandler, 1976, *The Art of Warfare in the Age of Marlborough*, London: Batsford (mentions the ballistics aspect).

CM

Bell, Alexander Graham

b. 3 March 1847 Edinburgh, Scotland

d. 3 August 1922 Beinn Bhreagh, Baddeck, Cape Breton Island, Nova Scotia, Canada

Scottish/American inventor of the telephone.

Bell's grandfather was a professor of elocution in London and his father an authority on the physiology of the voice and on elocution; Bell was to follow in their footsteps. He was educated in Edinburgh, leaving school at 13. In 1863 he went to Elgin, Morayshire, as a pupil teacher in elocution, with a year's break to study at Edinburgh University; it was in 1865, while still in Elgin, that he first conceived the idea of the electrical transmission of speech. He went as a master to Somersetshire College, Bath (now in Avon), and in 1867 he moved to London to assist his father, who had taken up the grandfather's work in elocution. In the same year, he matriculated at London University, studying anatomy and physiology, and also began teaching the deaf. He continued to pursue the studies that were to lead to the invention of the telephone. At this time he read Helmholtz's *The Sensations of Tone*, an important work on the theory of sound that was to exert a considerable influence on him.

In 1870 he accompanied his parents when they emigrated to Canada. His work for the deaf gained fame in both Canada and the USA, and in 1873 he was appointed professor of vocal physiology and the mechanics of speech at Boston University, Massachusetts. There, he continued to work on his theory that sound wave vibrations could be converted into a fluctuating electric current, be sent along a wire and then be converted back into sound waves by means of a receiver. He approached the problem from the background of the theory of sound and voice production rather than from that of electrical science, and by 1875 he had succeeded in constructing a rough model. On 7 March 1876 Bell spoke the famous command to his assistant, 'Mr Watson, come here, I want you': this was the first time a human voice had been transmitted along a wire. Only three days earlier, Bell's first patent for the telephone had been granted. Almost simultaneously, but quite independently, Elisha **Gray** had achieved a similar result. After a period of litigation, the US Supreme Court awarded Bell priority, although Gray's device was technically superior.

In 1877, three years after becoming a naturalized US citizen, Bell married the deaf daughter of his first backer. In August of that year, they travelled to Europe to combine a honeymoon with promotion of the telephone. Bell's patent was possibly the most valuable ever issued, for it gave birth to what later became the world's largest private service organization, the Bell Telephone Company.

Bell had other scientific and technological interests: he made improvements in telegraphy and in **Edison's** gramophone, and he also developed a keen interest in aeronautics, working on **Curtiss's** flying machine. Bell founded the celebrated periodical *Science*.

Principal Honours and Distinctions

Legion of Honour; Hughes Medal, Royal Society, 1913.

Further Reading

Obituary, 7 August 1922, *The Times*.

Dictionary of American Biography.

R. Burlingame, 1964, *Out of Silence into Sound*, London: Macmillan.

LRD

Bell, Henry

b. 1767 Torphichen Mill, near Linlithgow, Scotland

d. 1830 Helensburgh, Scotland

Scottish projector of the first steamboat service in Europe.

The son of Patrick Bell, a millwright, Henry had two sisters and an elder brother and was educated at the village school. When he was 9 years old Henry was sent to lodge in Falkirk with an uncle and aunt of his mother's so that he could attend the school there. At the age of 12 he left school and agreed to become a mason with a relative. In 1783, after only three years, he was bound apprentice to his Uncle Henry, a millwright at Jay Mill. He stayed there for a further three years and then, in 1786, joined the firm of Shaw & Hart, shipbuilders of Borrowstoneness. These were to be the builders of William **Symington's** hull for the *Charlotte Dundas*. He also spent twelve months with Mr James Inglis, an engineer of Bellshill, Lanarkshire, and then went to London to gain experience, working for the famous John **Rennie** for some eighteen months. By 1790 he was back in Glasgow, and a year later he took a partner, James Paterson, into his new business of builder and contractor, based in the Trongate. He later referred to himself as 'architect', and his partnership with Paterson lasted seven years. He is said to have invented a

discharging machine for calico printing, as well as a steam dredger for clearing the River Clyde.

The Baths Hotel was opened in Helensburgh in 1808, with the hotel-keeper, who was also the first provost of the town, being none other than Henry Bell. It has been suggested that Bell was also the builder of the hotel and this seems very likely. Bell installed a steam engine for pumping sea water out of the Clyde and into the baths, and at first ran a coach service to bring customers from Glasgow three days a week. The driver was his brother Tom. The coach was replaced by the *Comet* steamboat in 1812.

While Henry was busy with his provost's duties and making arrangements for the building of his steamboat, his wife Margaret, née Young, whom he married in March 1794, occupied herself with the management of the Baths Hotel. Bell did not himself manufacture, but supervised the work of experts: John and Charles Wood of Port Glasgow, builders of the 43ft 6 in. (13.25 m)-long hull of the *Comet*; David Napier of Howard Street Foundry for the boiler and other castings; and John Robertson of Dempster Street, who had previously supplied a small engine for pumping water to the baths at the hotel in Helensburgh, for the 3 hp engine. The first trials of the finished ship were held on 24 July 1812, when she was launched from Wood's yard. A regular service was advertised in the Glasgow Chronicle on 5 August and was the first in Europe, preceded only by that of Robert Fulton in the USA. The *Comet* continued to run until 1820, when it was wrecked.

Bell received little reward for his promotion of steam navigation, merely small pensions from the Clyde trustees and others. He was buried at the parish church of Rhu.

Further Reading

Edward Morris, 1844, *Life of Henry Bell* .

Henry Bell, 1813, *Applying Steam Engines to Vessels* .

IMcN

Bell, Imrie

b. 1836 Edinburgh, Scotland

d. 21 November 1906 Croydon, Surrey, England

Scottish civil engineer who built singular and pioneering structures.

Following education at the Royal High School of Edinburgh, Bell served an apprenticeship with a Mr Bertram, engineer and shipwright of Leith, before continuing as a regular pupil with Bell and Miller, the well-known civil engineers of Glasgow. A short period at Pelton Colliery in County Durham followed, and then at the early age of 20 Bell was appointed Resident Engineer on the construction of the Meadowside Graving Dock in Glasgow.

The Meadowside Dry Dock was opened on 28 January 1858 and was a remarkable act of faith by the proprietors Messrs Tod and McGregor, one of the earliest companies in iron shipbuilding in the British Isles. It was the first dry dock in the City of Glasgow and used the mouth of the river Kelvin for canting ships; at the time the dimensions of 144×19×5.5m depth were regarded as quite daring. This dock was to remain in regular operation for nearly 105 years and is testimony to the skills of Imrie Bell and his colleagues.

In the following years he worked for the East India Railway Company, where he was in charge of the southern half of the Jumna Railway Bridge at Allahabad, before going on to other exciting civil engineering contracts in India. On his return home, Bell became Engineer to Leith Docks, and three years later he became Executive Engineer to the States of Jersey, where he constructed St Helier's Harbour and the lighthouse at La Corbiere—the first in Britain to be built with Portland cement. In 1878 he rejoined his old firm of Bell and Miller, and ultimately worked from their Westminster office. One of his last jobs in Scotland was supervising the building of the Great Western Road Bridge in Glasgow, one of the beautiful bridges in the West End of the city.

Bell retired from business in 1898 and lived in Surrey for the rest of his life.

Bibliography

1879–80, 'On the St Helier's Harbour works', *Transactions of the Institution of Engineers and Shipbuilders in Scotland* 23.

Further Reading

Fred M. Walker, 1984, *Song of the Clyde*, Cambridge: PSL.

FMW

Bell, Sir Isaac Lowthian

b. 15 February 1816 Newcastle upon Tyne, England

d. 20 December 1904 Rounton Grange, Northallerton, Yorkshire, England

English ironworks proprietor, chemical manufacturer and railway director, widely renowned for his scientific pronouncements.

Following an extensive education, in 1835 Bell entered the Tyneside chemical and iron business where his father was a partner; for about five years from 1845 he controlled the ironworks. In 1844, he and his two brothers leased an iron blast-furnace at Wylam on Tyne. In 1850, with partners, he started chemical works at Washington, near Gateshead. A few years later, with his two brothers, he set up the Clarence Ironworks on Teesside. In the 1880s, salt extraction and soda-making were added there; at that time the Bell

Brothers' enterprises, including collieries, employed 6,000 people.

Lowthian Bell was a pioneer in applying thermochemistry to blast-furnace working. Besides his commercial interests, scientific experimentation and international travel, he found time to take a leading part in the promotion of British technical organizations; upon his death he left evidence of a prodigious level of personal activity.

Principal Honours and Distinctions

Created baronet 1885. FRS 1875. Légion d'honneur 1878. MP, Hartlepool, 1875–80. President: British Iron Trade Association; Iron and Steel Institute; Institution of Mechanical Engineers; North of England Institute of Mining and Mechanical Engineers; Institution of Mining Engineers; Society of the Chemical Industry. Iron and Steel Institute Bessemer Gold Medal 1874 (the first recipient). Society of Arts Albert Medal 1895.

Bibliography

The first of several books, Bell's *Chemical Phenomena of Iron Smelting...* (1872), was soon translated into German, French and Swedish. He was the author of more than forty technical articles.

Further Reading

1900–1910, *Dictionary of National Biography*.

C. Wilson, 1984, article in *Dictionary of Business Biography*, Vol. I, ed. J. Jeremy, Butterworth (a more discursive account).

D. Burn, 1940, *The Economic History of Steelmaking, 1867–1939: A Study in Competition*, Cambridge (2nd edn 1961).

JKA

Bell, Revd Patrick

b. 1799 Auchterhouse, Scotland

d. 22 April 1869 Carmyllie, Scotland

Scottish inventor of the first successful reaping machine.

The son of a Forfarshire tenant farmer, Patrick Bell obtained an MA from the University of St Andrews. His early association with farming kindled an interest in engineering and mechanics and he was to maintain a workshop not only on his father's farm, but also, in later life, at the parsonage at Carmyllie.

He was still studying divinity when he invented his reaping machine. Using garden shears as the basis of his design, he built a model in 1827 and a full-scale prototype the following year. Not wishing the machine to be seen during his early experiments, he and his brother planted a sheaf of oats in soil laid out in a shed, and first tried the machine on this. It cut well enough but left the straw in a mess behind it. A canvas belt system was devised and another secret trial in the barn was followed by a night excursion into a field, where corn was successfully harvested.

Two machines were at work during 1828, apparently achieving a harvest rate of one acre per hour. In 1832 there were ten machines at work, and at least another four had been sent to the United States by this time. Despite their success Bell did not patent his design, feeling that the idea should be given free to the world. In later years he was to regret the decision, feeling that the many badly-made imitations resulted in its poor reputation and prevented its adoption.

Bell's calling took precedence over his inventive interests and after qualifying he went to Canada in 1833, spending four years in Fergus, Ontario. He later returned to Scotland and became the minister at Carnyllie, with a living of £150 per annum.

Principal Honours and Distinctions

Late in the day he was honoured for his part in the development of the reaping machine. He received an honorary degree from the University of St Andrews and in 1868 a testimonial and £1,000 raised by public subscription by the Highland and Agricultural Society of Scotland.

Bibliography

1854, *Journal of Agriculture* (perhaps stung by other claims, Bell wrote his own account).

Further Reading

G.Quick and W.Buchele, 1978, *The Grain Harvesters*, American Society of Agricultural Engineers (gives an account of the development of harvesting machinery).

L.J.Jones, 1979, *History of Technology*, pp. 101–48 (gives a critical assessment of the various claims regarding the originality of the invention).

J.Hendrick, 1928, *Transactions of the Highland and Agricultural Society of Scotland*, pp. 51–69 (provides a celebration of Bell's achievement on its centenary).

AP

Bell, Thomas

fl. 1770–1785 Scotland

Scottish inventor of a calico printing machine with the design engraved on rollers.

In November 1770, John Mackenzie, owner of a bleaching mill, took his millwright Thomas Bell to Glasgow to consult with James **Watt** about problems they were having with the calico printing machine invented by Bell some years previously. Bell rolled sheets of copper one eighth of an inch (3 mm) thick into cylinders, and filled them with cement which was held in place by cast iron ends. After being turned true and polished, the cylinders were engraved; they cost about £10 each. The printing machines were driven by a water-wheel, but Bell and Mackenzie appeared to have had problems with the doctor blades which scraped off excess colour, and this may have been why they visited Watt.

They had, presumably, solved the technical problems when Bell took out a patent in 1783 which describes him as 'the Elder', but there are no further details about the man himself. The machine is described as having six printing rollers arranged around the top of the circumference of a large central bowl. In later machines, the printing rollers were placed all round a smaller cylinder. All of the printing rollers, each printing a different colour, were driven by gearing to keep them in register. The patent includes steel doctor blades which would have scraped excess colour off the printing rollers. Another patent, taken out in 1784, shows a smaller three-colour machine. The printing rollers had an iron core covered with copper, which could be taken off at pleasure so that fresh patterns could be cut as desired. Bell's machine was used at Masney, near Preston, England, by Messrs Livesey, Hargreaves, Hall & Co in 1786. Although copper cylinders were difficult to make and engrave, and the soldered seams often burst, these machines were able to increase the output of the cheaper types of printed cloth.

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1784, patent no. 1,443 (three-colour calico printing machine).

Further Reading

W.E.A.Axon, 1886, *Annals of Manchester*, Manchester (provides an account of the invention).
R.L.Hills, 1970, *Power in the Industrial Revolution*, Manchester (provides a brief description of the development of calico printing).

RLH

Belling, Charles Reginald

b. 11 May 1884 Bodmin, Cornwall, England

d. 8 February 1965 while on a cruise

English electrical engineer best known as the pioneer of the wire-wound clay-former heating element which made possible the efficient domestic electric fire.

Belling was educated at Burts Grammar School in Lostwithiel, Cornwall, and at Crossley Schools in Halifax, Yorkshire. In 1903 he was apprenticed to Crompton & Co. at Chelmsford in Essex, the firm that in 1894 offered for sale the earliest electric heaters. These electric radiant panels were intended as heating radiators or cooking hotplates, but were not very successful because, being cast-iron panels into which heating wires had been embedded in enamel, they tended to fracture due to the different rates of thermal expansion of the iron and the enamel. Other designs of electric heaters followed, notably the introduction of large, sausage-shaped carbon filament bulbs fitted into a fire frame and backed by reflectors. This was the idea of H. Dowsing, a collaborator of **Crompton**, in 1904.

After qualifying in 1906, Belling left Crompton & Co. and went to work for Ediswan at Ponders End in Hertfordshire. He left in 1912 to set up his own business, which he began in a small shed in Enfield. With a small staff and capital of £450, he took out his first patent for his wire-wound-former electric fire in the same year. The resistance wire, made from nickel-chrome alloy such as that patented in 1906 by A.L. Marsh, was coiled round a clay former. Six such bars were attached to a cast-iron frame with heating control knobs, and the device was marketed as the Standard Belling Fire. Advertised in 1912, the fire was an immediate success and was followed by many other variations. Improvements to the first model included wire safety guards, enamel finishes and a frame ornamented with copper and brass.

Belling turned his attention to hotplates, cookers, immersion heaters, electric irons, water urns and kettles, producing the Modernette Cooker (1919), the multi-parabola fire bar (1921), the plate and dish warmer (1924), the storage heater (1926) and the famous Baby Belling cookers, the first of which appeared in 1929. By 1955 business had developed so well that Belling opened another factory at Burnley, Lancashire. He partly underwrote, for the amount of £1 million, a proposed scientific technical college for the electrical industry at Enfield.

Further Reading

1985, *Dictionary of Business Biography*, Butterworth.

G.Jukes, 1963, *The Story of Belling*, Belling and Co. Ltd (produced by the company in its Golden Jubilee year).

DY

Bennett, Charles Harper

b. 1840 Clapham, London, England

d. 1927 Sydney, Australia

English inventor of the 'ripening' technique for increasing the sensitivity of gelatine silver halide emulsions.

The son of a hatter, Bennett studied medicine and was interested in mechanical devices, chemistry and later photography. An interior view shown at a South London Photographic Society meeting in March 1878 prompted requests for details of Bennett's procedure, and these were published almost immediately. It involved heating gelatine silver bromide for extremely long periods with an excess of silver bromide. The resulting emulsion had greatly enhanced sensitivity. This 'ripening' process proved to be a major advance in the development of modern photographic emulsions. It was not patented and was soon widely adopted. Bennett's process became a key factor in the establishment of a new industry, the mass production of gelatine dry plates.

Bibliography

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Further Reading

H.Gernsheim and A.Gernsheim, 1969, *The History of Photography*, rev. edn, London.

JW

Bentham, Sir Samuel

b. 11 January 1757 England

d. 31 May 1831 London, England

English naval architect and engineer.

He was the son of Jeremiah Bentham, a lawyer. His mother died when he was an infant and his early education was at Westminster. At the age of 14 he was apprenticed to a master shipwright at Woolwich and later at Chatham Dockyard, where he made some small improvements in the fittings of ships. In 1778 he completed his apprenticeship and sailed on the *Bienfaisant* on a summer cruise of the Channel Fleet where he suggested and supervised several improvements to the steering gear and gun fittings.

Unable to find suitable employment at home, he sailed for Russia to study naval architecture and shipbuilding, arriving at St Petersburg in 1780, whence he travelled

throughout Russia as far as the frontier of China, examining mines and methods of working metals. He settled in Kritchev in 1782 and there established a small shipyard with a motley work-force. In 1784 he was appointed to command a battalion. He set up a yard on the 'Panopticon' principle, with all workshops radiating from his own central office. He increased the armament of his ships greatly by strengthening the hulls and fitting guns without recoil, which resulted in a great victory over the Turks at Liman in 1788. For this he was awarded the Cross of St George and promoted to Brigadier-General. Soon after, he was appointed to a command in Siberia, where he was responsible for opening up the resources of the country greatly by developing river navigation.

In 1791 he returned to England, where he was at first involved in the development of the Panopticon for his brother as well as with several other patents. In 1795 he was asked to look into the mechanization of the naval dockyards, and for the next eighteen years he was involved in improving methods of naval construction and machinery. He was responsible for the invention of the steam dredger, the caisson method of enclosing the entrances to docks, and the development of non-recoil cannonades of large calibre.

His intervention in the maladministration of the naval dockyards resulted in an enquiry that brought about the clearing-away of much corruption, making him very unpopular. As a result he was sent to St Petersburg to arrange for the building of a number of ships for the British navy, in which the Russians had no intention of co-operating. On his return to England after two years he was told that his office of Inspector-General of Navy Works had been abolished and he was appointed to the Navy Board; he had several disagreements with John **Rennie** and in 1812 was told that this office, too, had been abolished. He went to live in France, where he stayed for thirteen years, returning in 1827 to arrange for the publication of some of his papers.

There is some doubt about his use of his title: there is no record of his having received a knighthood in England, but it was assumed that he was authorized to use the title, granted to him in Russia, after his presentation to the Tsar in 1809.

Further Reading

Mary Sophia Bentham, *Life of Brigadier-General Sir Samuel Bentham, K.S.G., Formerly Inspector of Naval Works* (written by his wife, who died before completing it; completed by their daughter).

IMcN

Bentley, John Francis

b. 30 January 1839 Doncaster, Yorkshire, England

d. 2 March 1902 Clapham, London, England

English architect who specialized chiefly in ecclesiastical building, especially

Roman Catholic churches.

Bentley's work was of high quality, particularly with regard to the decorative materials and finish. Notable among his churches was the Church of the Holy Rood (begun in 1887) at Watford, which is in Gothic Revival style, with fine decorative materials.

Bentley's *chef-d'oeuvre* is the Roman Catholic Cathedral of Westminster in London: begun in 1895, the shell was completed in 1903. He based the banded pattern of the exterior upon the Italian medieval cathedrals of Siena and Orvieto, but at Westminster the banding is in red brick and white stone instead of marble. The cathedral interior is Byzantine in style, with pendentive construction. Built of load-bearing brick, with the saucer domes inside being made of concrete strengthened with brick inserts, there is no steel reinforcement: in choosing this type of structural material, Bentley was more closely following ancient Roman technology than modern use of concrete. The intention was to have all surfaces clad in mosaic of marble, but sadly only a portion of this has yet been achieved.

Principal Honours and Distinctions

Bentley was nominated in 1902 to receive the RIBA Gold Medal but died before the presentation ceremony.

Further Reading

W.de l'Hopital, 1919, *Westminster Cathedral and its Architect*, Hutchinson.

DY

Benton, Linn Boyd

b. 13 May 1844 Little Falls, New York, USA

d. 15 July 1932 Plainfield, New Jersey, USA

American typefounder, cutter and designer, inventor of the automatic punch-cutting machine.

Benton spent his childhood in Milwaukee and La Crosse, where he early showed a talent for mechanical invention. His father was a lawyer with an interest in newspapers and who acquired the Milwaukee *Daily News*. Benton became familiar with typesetting equipment in his father's newspaper office. He learned the printer's trade at another newspaper office, at La Crosse, and later worked as bookkeeper at a type foundry in Milwaukee. When that failed in 1873, Benton acquired the plant, and when he was joined by R.V.Waldo the firm became Benton, Waldo & Co. Benton began learning and improving type-cutting practice. He first devised unit-width or 'self-spacing' type which became

popular with compositors, saving, it was reckoned, 20 per cent of their time. Meanwhile, Benton worked on a punch-cutting machine to speed up the process of cutting letters in the steel punches from which matrices or moulds were formed to enable type to be cast from molten metal. His first mechanical punch-cutter worked successfully in 1884. The third machine, patented in 1885, was the model that revolutionized the typefounding operation. So far, punch-cutting had been done by hand, a rare and expensive skill that was insufficient to meet the demands of the new typesetting machines, the monotype of **Lanston** and the linotype of **Mergenthaler**. These were threatened with failure until Benton saved the day with his automatic punch-cutter. Mechanizing punch-cutting and the forming of matrices made possible the typesetting revolution brought about by mono- and linotype.

In 1892 Benton's firm merged with others to form the American Type Founders Company. Benton's equipment was moved to New York and he with it, to become a board member and Chief Technical Advisor. In 1894 he became Manager of the company's new plant for type manufacture in Jersey City. Benton steadily improved both machinery and processes, for which he was granted twenty patents. With his son Morris Fuller, he was also notable and prolific in the field of type design. Benton remained in active association with his company until just two weeks before his death.

Further Reading

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H.L.Bullen, 1922, *Inland Printer* (October) (describes Benton's life and work).

LRD

Benz, Karl

b. 25 November 1844 Pfaffenrot, Black Forest, Germany

d. 4 April 1929 Ladenburg, near Mannheim, Germany

German inventor of one of the first motor cars.

The son of a railway mechanic, it is said that as a child one of his hobbies was the repair of Black Forest clocks. He trained as a mechanical engineer at the Karlsruhe Lyzeum and Polytechnikum under Ferdinand Redtenbacher (d. 1863), who pointed out to him the need for a more portable power source than the steam engine. He went to Maschinenbau Gesellschaft Karlsruhe for workshop experience and then joined Schweizer & Cie, Mannheim, for two years. In 1868 he went to the Benkiser Brothers at Pforzheim. In 1871 he set up a small machine-tool works at Mannheim, but in 1877, in financial

difficulties, he turned to the idea of an entirely new product based on the internal-combustion engine. At this time, N.A. **Otto** held the patent for the four-stroke internal-combustion engine, so Benz had to put his hopes on a two-stroke design. He avoided the trouble with Dugald **Clerk**'s engine and designed one in which the fuel would not ignite in the pump and in which the cylinder was swept with fresh air between each two firing strokes. His first car had a sparking plug and coil ignition. By 1879 he had developed the engine to a stage where it would run satisfactorily with little attention. On 31 December 1879, with his wife Bertha working the treadle of her sewing machine to charge the batteries, he demonstrated his engine in street trials in Mannheim. In the summer of 1888, unknown to her husband, Bertha drove one of his cars the 80 km (50 miles) to Pforzheim and back with her two sons, aged 13 and 15. She and the elder boy pushed the car up hills while the younger one steered. They bought petrol from an apothecary in Wiesloch and had a brake block repaired in Bauschlott by the village cobbler. Karl Benz's comments on her return from this venture are not recorded!

Financial problems prevented immediate commercial production of the automobile, but in 1882 Benz set up the Gasmotorenfabrik Mannheim. After trouble with some of his partners, he left in 1883 and formed a new company, Benz & Cie, Rheinische Gasmotorenfabrik. Otto's patent was revoked in 1886 and in that year Benz patented a motor car with a gas engine drive. He manufactured a 0.8hp car, the engine running at 250 rpm with a horizontal flywheel, exhibited at the Paris Fair in 1889. He was not successful in finding anyone in France who would undertake manufacture. This first car was a three-wheeler, and soon after he produced a four-wheeled car, but he quarrelled with his co-directors, and although he left the board in 1902 he rejoined it soon after.

Further Reading

St J.Nixon, 1936, *The Invention of the Automobile*.

E.Diesel *et al.*, 1960, *From Engines to Autos*.

E.Johnson, 1986, *The Dawn of Motoring*.

IMcN

Berezin, Evelyn

b. 1925 New York, USA

American pioneer in computer technology.

Born into a poor family in the Bronx, New York City, Berezin first majored in business studies but transferred her interest to physics. She graduated in 1946 and then, with the aid of an Atomic Energy Commission fellowship, she obtained her PhD in cosmic ray physics at New York University. When the fellowship expired, opportunities in the developing field of electronic data processing seemed more promising than these in

physics. Berezin entered the firm of Electronic Computer Corporation in 1951 and was asked to 'build a computer', although few at that time had actually seen one; the result was the Elecom 200. In 1953, for Underwood Corporation, she designed the first office computer, although it was never marketed, as Underwood sold out to Olivetti.

Berezin's next position was as head of logic design for Teleregister Corporation in the late 1950s. Here, she led a team specializing in the design of on-line systems. Her most notable achievement was the design of a nationwide online computer reservation system for United Airlines, the first system of this kind and the precursor of similar on-line systems. It was installed in the early 1960s and was the first large non-military on-line interactive system.

In the 1960s Berezin moved to the Digitronics Corporation as manager of logic design, her work here resulted in the first high-speed commercial digital communications terminal. Also in the 1960s, her involvement in Data Secretary, a challenger to the IBM editing typewriter, makes it possible to regard her as one of the pioneers of word processing. In 1976 Berezin transferred from the electronic data and computing field to that of financial management.

Further Reading

A. Stanley, 1993, *Mothers and Daughters of Invention*, Meruchen, NJ: Scarecrow Press, 651–3.

LRD

Berger, Hans

b. 21 May 1873 Neuses bei Coburg, Germany

d. 1 June 1941 Jena, Germany

German psychiatrist and neurophysiologist, discoverer of the human electroencephalogram (EEG).

Berger studied medicine at the University of Jena from 1892. In 1897 he became Assistant to the psychiatric clinic, in 1912 he became Chief Doctor and then Director and Professor of Psychiatry, remaining in this post until his retirement in 1938.

The central theme of his research work was the correlation between the objective activity of the brain and subjective psychic phenomena. His early attempts involving the blood flow and temperature of the brain yielded no positive results, and it was not until 1929 that he had developed methods of recording the fluctuations of electric potential arising from brain activity. This electroencephalogram (EEG) proved to be of immediate value in the diagnosis and treatment of brain disease, but it did not prove to be an indicator of a connection between brain and psychic energy.

Although Berger continued to study the EEC intensively, the technique did not gain

widespread recognition until its development by Adrian and Matthews from 1934 onwards.

Bibliography

Various papers, including 'Über das Elektrenkephalogramm des Menschens', *Archiv für Psychiatrie*, 1929–38.

Further Reading

Adrian and Matthews, 1934, 'The Berger Rhythm', *Brain* .

MG

Bergius, Friedrich Carl Rudolf

b. 11 October 1884 Goldschmieden, near Breslau, Germany

d. 31 March Buenos Aires, Argentina

German chemist who invented the coal-liquefaction process

After studying chemistry in Breslau and Leipzig and assisting *inter alia* at the institute of Fritz Haber in Karlsruhe on the catalysis of ammonia under high pressure, in 1909 he went to Hannover to pursue his idea of turning coal into liquid hydrocarbon under high hydrogen pressure (200 atm) and high temperatures (470° C). As experiments with high pressure in chemical processes were still in their initial stages and the Technical University could not support him sufficiently, he set up a private laboratory to develop the methods and to construct the equipment himself. Four years later, in 1913, his process for producing liquid or organic compounds from coal was patented.

The economic aspects of this process were apparent as the demand for fuels and lubricants increased more rapidly than the production of oil, and Bergius's process became even more important after the outbreak of the First World War. The Th. Goldschmidt company of Essen contracted him and tried large-scale production near Mannheim in 1914, but production failed because of the lack of capital and experience to operate with high pressure on an industrial level. Both capital and experience were provided jointly by the BASF company, which produced ammonia at Merseburg, and IG Farben, which took over the Bergius process in 1925, the same year that the synthesis of hydrocarbon had been developed by Fischer-Tropsch. Two years later, at the Leuna works, almost 100,000 tonnes of oil were produced from coal; during the following years, several more hydrogenation plants were to follow, especially in the eastern parts of Germany as well as in the Ruhr area, while the government guaranteed the costs. The Bergius process was extremely important for the supply of fuels to Germany during the

Second World War, with the monthly production rate in 1943–4 being more than 700,000 tonnes. However, the plants were mostly destroyed at the end of the war and were later dismantled.

As a consequence of this success Bergius, who had gained an international reputation, went abroad to work as a consultant to several foreign governments. Experiments aiming to reduce the costs of production are still continued in some countries. By 1925, after he had solved all the principles of his process, he had turned to the production of dextrose by hydrolyzing wood with highly concentrated hydrochloric acid.

Principal Honours and Distinctions

Nobel Prize 1931. Honorary doctorates, Heidelberg, Harvard and Hannover.

Bibliography

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W.Birkendfeld, 1964, *Der synthetische Treibstoff 1933–1945. Ein Beitrag zur nationalsozialistischen Wirtschafts- und Rüstungspolitik*, Göttingen, Berlin and Frankfurt (describes the economic value of synthetic fuels for the Third Reich).

WK

Berliner, Emile

b. 20 May 1851 Hannover, Germany

d. 3 August 1929 Montreal, Canada

German (naturalized American) inventor, developer of the disc record and lateral mechanical replay.

After arriving in the USA in 1870 and becoming an American citizen, Berliner worked as a dry-goods clerk in Washington, DC, and for a period studied electricity at Cooper Union for the Advancement of Science and Art, New York. He invented an improved microphone and set up his own experimental laboratory in Washington, DC. He developed a microphone for telephone use and sold the rights to the Bell Telephone Company. Subsequently he was put in charge of their laboratory, remaining in that position for eight years. In 1881 Berliner, with his brothers Joseph and Jacob, founded the J.Berliner Telephonfabrik in Hanover, the first factory in Europe specializing in telephone equipment.

Inspired by the development work performed by T.A. **Edison** and in the **Volta** Laboratory (see C.S. **Tainter**), he analysed the existing processes for recording and reproducing sound and in 1887 developed a process for transferring lateral undulations scratched in soot into an etched groove that would make a needle and diaphragm vibrate. Using what may be regarded as a combination of the Phonautograph of Léon **Scott de Martinville** and the photo-engraving suggested by Charles **Cros**, in May 1887 he thus demonstrated the practicability of the laterally recorded groove. He termed the apparatus 'Gramophone'. In November 1887 he applied the principle to a glass disc and obtained an inwardly spiralling, modulated groove in copper and zinc. In March 1888 he took the radical step of scratching the lateral vibrations directly onto a rotating zinc disc, the surface of which was protected, and the subsequent etching created the groove. Using well-known principles of printing-plate manufacture, he developed processes for duplication by making a negative mould from which positive copies could be pressed in a thermoplastic compound. Toy gramophones were manufactured in Germany from 1889 and from 1892–3 Berliner manufactured both records and gramophones in the USA. The gramophones were hand-cranked at first, but from 1896 were based on a new design by E.R. **Johnson** . In 1897–8 Berliner spread his activities to England and Germany, setting up a European pressing plant in the telephone factory in Hanover, and in 1899 a Canadian company was formed. Various court cases over patents removed Berliner from direct running of the reconstructed companies, but he retained a major economic interest in E.R. Johnson's Victor Talking Machine Company. In later years Berliner became interested in aeronautics, in particular the autogiro principle. Applied acoustics was a continued interest, and a tile for controlling the acoustics of large halls was successfully developed in the 1920s.

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US patent no. 534,543 (hand-cranked gramophone).

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 J.R.Smart, 1985, 'Emile Berliner and nineteenth-century disc recordings', in *Wonderful Inventions*, ed. Iris Newson, Washington, DC: Library of Congress, pp. 346–59 (provides a reliable account).
 O.Read and W.L.Welch, 1959, *From Tin Foil to Stereo*, Indianapolis: Howard W.Sams, pp. 119–35 (provides a vivid account, albeit with less precision).

GB-N

Berry, George

b. Missouri, USA
 fl. 1880s

American farmer who developed the first steam-powered, self-propelled combine harvester.

Born in Missouri, George Berry moved to a 4,000 acre (1,600 hectare) farm at Lindsay in California, and between 1881 and 1886 built himself a steam-driven combine harvester. Berry's machine was the first self-propelled harvester and the first to use straw as a fuel. A single boiler powered two engines: a 26 hp (19 kW) Mitchell Fisher engine provided the forward drive, whilst a 6 hp (4 kW) **Westinghouse** engine drove the threshing mechanism. Cleaned straw was passed by conveyor back to the firebox, where it provided the main fuel. The original machine had a 22 ft cut, but a later machine extended this to 40 ft and harvested 50 acres a day, although on one occasion it achieved the distinction of being the first harvester to cut over 100 acres in one day. The traction engine used for motive power was removable and was used after harvest for ploughing. It was the first engine to be capable of forward and reverse motion.

In later life Berry moved into politics, becoming a member of the California Senate for Inyo and Tulare in the 1890s.

Further Reading

- G.Quick and W.Buchele, 1978, *The Grain Harvesters*, American Society of Agricultural Engineers (gives an account of combine-harvester development).

AP

Berry, Henry

b. 1720 Parr (?), near St Helens, Lancashire, England

d. 30 July 1812 Liverpool, England

English canal and dock engineer who was responsible for the first true canal, as distinct from a canalized river, in England.

Little is known of Berry's early life, but it is certain that he knew the district around St Helens intimately, which was of assistance to him in his later canal works. He became Clerk and Assistant to Thomas **Steers** and proved his natural engineering ability in helping Steers in both the construction of the Newry navigation in Ireland and his supervision of the construction of Salthouse Dock in Liverpool. On Steers's death in 1750 Berry was appointed, at the age of 30, Dock Engineer for Liverpool Docks, and completed the Salthouse Dock three years later. In 1755 he was allowed by the Liverpool Authority—presumably because his full-time service was not required at the docks at that time—to survey and construct the Sankey Brook Navigation (otherwise known as the St Helens Canal), which was completed in 1757. Berry was instructed to make the brook navigable, but with the secret consent and connivance of one of the proprietors he built a lateral canal, the work commencing on 5 September 1755. This was the first dead-water canal in the country, as distinct from an improved river navigation, and preceded **Brindley's** Bridgewater Canal by some five or six years. On the canal he also constructed at Blackbrook the first pair of staircase locks to be built in England.

Berry later advised on improvements to the Weaver Navigation, and his design for the new locks was accepted. He also carried out in 1769 a survey for a Leeds and Liverpool Canal, but this was not proceeded with and it was left to others to construct this canal. He advised turnpike trustees on bridge construction, but his main work was in Liverpool dock construction and between 1767 and 1771 he built the George's Dock. His final dock work was King's Dock, which was opened on 3 October 1788; he resigned at the age of 68 when the dock was completed. He lived for another 24 years, during which he was described in the local directories as 'gentleman' instead of 'engineer' or 'surveyor' as he had been previously.

Further Reading

S.A.Harris, 1937, 'Liverpool's second dock engineer', *Transactions of the Historic Society of Lancashire and Cheshire* 89.

Berthollet, Claude-Louis

b. 9 November 1748 Talloise, near Lake Annecy, France

d. 6 November 1822 Arceuil, France

French chemist who made important innovations in textile chemistry.

Berthollet qualified as a medical doctor and pursued chemical researches, notably into 'muriatic acid' (chlorine), then recently discovered by **Scheele**. He was one of the first chemists to embrace the new system of chemistry advanced by **Lavoisier**. Berthollet held several official appointments, among them inspector of dye works (from 1784) and Director of the Manufacture Nationale des Gobelins. These appointments enabled him to continue his researches and embark on a series of publications on the practical applications of chlorine, prussic acid (hydrocyanic acid) and ammonia. He clearly demonstrated the benefits of the French practice of appointing scientists to the state manufactories.

There were two practical results of Berthollet's studies of chlorine. First, he produced a powerful explosive by substituting potassium chlorate, formed by the action of chlorine on potash, in place of nitre (potassium nitrate) in gunpowder. Then, mainly from humanitarian motives, he followed up Scheele's observation of the bleaching properties of chlorine water, in order to release for cultivation the considerable areas of land that had hitherto been required by the old bleaching process. The chlorine method greatly speeded up bleaching; this was a vital factor in the revolution in the textile industries.

After a visit to Egypt in 1799, Berthollet carried out many experiments on dyeing, seeking to place this ancient craft onto a scientific basis. His work is summed up in his *Eléments de l'art de la teinture*, Paris, 1791.

Bibliography

1791, *Eléments de Van de la teinture*, Paris (covers his work on dyeing).

Berthollet published two books of importance in the early history of physical chemistry:

1801, *Recherches sur les lois de l'affinité*, Paris.

1803, *Essai de statique chimique*, Paris.

His scientific papers appeared mainly in *Mémoires de l'Académie Royal des Sciences* and *Annales de Chimie*.

Further Reading

E.F.Jomard, 1844, *Notice sur la vie et les ouvrages de Claude-Louis Berthollet*, Annecy.

E.Farber, 1961, *Great Chemists*, New York: Interscience, pp. 32–4 (includes a short biographical account).

Bessemer, Sir Henry

b. 19 January 1813 Charlton (near Hitchin), Hertfordshire, England

d. 15 January 1898 Denmark Hill, London, England

English inventor of the Bessemer steelmaking process.

The most valuable part of Bessemer's education took place in the workshop of his inventor father. At the age of only 17 he went to London to seek his fortune and set himself up in the trade of casting art works in white metal. He went on to the embossing of metals and other materials and this led to his first major invention, whereby a date was incorporated in the die for embossing seals, thus preventing the wholesale forgeries that had previously been committed. For this, a grateful Government promised Bessemer a paid position, a promise that was never kept; recognition came only in 1879 with a belated knighthood. Bessemer turned to other inventions, mainly in metalworking, including a process for making bronze powder and gold paint. After he had overcome technical problems, the process became highly profitable, earning him a considerable income during the forty years it was in use.

The Crimean War presented inventors such as Bessemer with a challenge when weaknesses in the iron used to make the cannon became apparent. In 1856, at his Baxter House premises in St Paneras, London, he tried fusing cast iron with steel. Noticing the effect of an air current on the molten mixture, he constructed a reaction vessel or converter in which air was blown through molten cast iron. There was a vigorous reaction which nearly burned the house down, and Bessemer found the iron to be almost completely decarburized, without the slag threads always present in wrought iron. Bessemer had in fact invented not only a new process but a new material, mild steel. His paper 'On the manufacture of malleable iron and steel without fuel' at the British Association meeting in Cheltenham later that year created a stir. Bessemer was courted by ironmasters to license the process. However, success was short-lived, for they found that phosphorus in the original iron ore passed into the metal and rendered it useless. By chance, Bessemer had used in his trials pig-iron, derived from haematite, a phosphorus-free ore. Bessemer tried hard to overcome the problem, but lacking chemical knowledge he resigned himself to limiting his process to this kind of pig-iron. This limitation was removed in 1879 by Sidney Gilchrist **Thomas**, who substituted a chemically basic lining in the converter in place of the acid lining used by Bessemer. This reacted with the phosphorus to form a substance that could be tapped off with the slag, leaving the steel free from this harmful element. Even so, the new material had begun to be applied in engineering, especially for railways. The open-hearth process developed by **Siemens** and the **Martin** brothers complemented rather than competed with Bessemer steel. The widespread use of the two processes had a revolutionary effect on mechanical and

structural engineering and earned Bessemer around £1 million in royalties before the patents expired.

Principal Honours and Distinctions

Knighthood 1879. FRS 1879. Royal Society of Arts Albert Gold Medal 1872.

Bibliography

1905, *Sir Henry Bessemer FRS: An Autobiography*, London.

LRD

Bettini, Gianni

b. 1860 Novara, Italy

d. 27 February 1938 San Remo, Italy

Italian developer of equipment for recording, duplicating and reproducing phonograph cylinders.

He was a nobleman and an Italian cavalry lieutenant and went to the USA, where he married Daisy Abbott (of Stamford, Connecticut). From 1888 he made amateur recordings of a wide circle of artistic acquaintances and improved the recording diaphragm attachment by the development of a 'spider' (a mechanical link that attacks the diaphragm in several points on its surface, rather than in the centre only). From 1892, through the Bettini Phonograph Laboratories, he published recordings of operatic artists and selections, and this led to the development of improved duplicating techniques by the so-called pantographic method. In 1901 he sold his US company and moved to Paris, although he continued to publish both cylinders and discs. In 1908 Bettini made a venture into cinematography, without success.

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US patent no. 409,003 (the 'spider' device).

US patent no. 488,381 (duplication).

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GB-N

Bevan, Edward John

b. 11 December 1856 Birkenhead, England

d. 17 October 1921 London, England

English co-inventor of the 'viscose rayon' process for making artificial silk.

Bevan began his working life as a chemist in a soap works at Runcorn, but later studied chemistry at Owens College, Manchester. It was there that he met and formed a friendship with C.F. **Cross**, with whom he started to work on cellulose. Bevan moved to a paper mill in Scotland but then went south to London, where he and Cross set up a partnership in 1885 as consulting and analytical chemists. Their work was mainly concerned with the industrial utilization of cellulose, and with the problems of the paper and jute industries. Their joint publication, *A Text-book of Paper-making*, which first appeared in 1888 and went into several editions, became the standard reference and textbook on the subject. The book has a long introductory chapter on cellulose.

In 1892 Cross, Bevan and Clayton Beadle discovered viscose, or sodium cellulose xanthate, and took out the patent which was to be the foundation of the 'viscose rayon' industry. They had their own laboratory at Station Avenue, Kew Gardens, where they carried out much work that eventually resulted in viscose: cellulose, usually in the form of wood pulp, was treated first with caustic soda and then with carbon disulphide to form the xanthate, which was then dissolved in a solution of dilute caustic soda to produce a viscous liquid. After being aged, the viscose was extruded through fine holes in a spinneret and coagulated in a dilute acid to regenerate the cellulose as spinnable fibres. At first there was no suggestion of spinning it into fibre, but the hope was to use it for filaments in incandescent electric light bulbs. The sheen on the fibres suggested their possible use in textiles and the term 'artificial silk' was later introduced. Cross and Bevan also discovered the acetate 'Celanese', which was cellulose triacetate dissolved in acetone and spun in air, but both inventions needed much development before they could be produced commercially.

In 1892 Bevan turned from cellulose to food and drugs and left the partnership to become Public Analyst to Middlesex County Council, a post he held until his death, although in 1895 he and Cross published their important work *Cellulose*. He was prominent in the affairs of the Society of Public Analysts and became one of its officials.

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1892, with C.F. Cross and C. Beadle, British patent no. 8,700 (viscose).

1895, with C.F. Cross, *Cellulose* .

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Edwin J.Beer, 1962–3, ‘The birth of viscose rayon’, *Transactions of the Newcomen Society* 35 (an account of the problems of developing viscose rayon; Beer worked under Cross in the Kew laboratories).

RLH

Bewick, Thomas

b. August 1753 Cherryburn House, Ovingham, Northumberland, England

d. 8 November 1828 Gateshead, England

English perfecter of wood-engraving.

The son of a farmer, Bewick was educated locally, but his progress was unremarkable save for demonstrating an intense love of nature and of drawing. In 1767 he was apprenticed to Ralph Beilby, an engraver in Newcastle. Wood-engraving at that time was at a low ebb, restricted largely to crude decorative devices, and Hogarth, commenting on a recent book on the art, doubted whether it would ever recover. Beilby’s business was of a miscellaneous character, but Bewick’s interest in wood-engraving was noticed and encouraged: Beilby submitted several of his engravings to the Royal Society of Arts, which awarded a premium of £80 for them. His apprenticeship ended in 1774 and he went to London, where he readily found employment with several printers. The call of the north was too strong, however, and two years later he returned to Newcastle, entering into partnership with Beilby. With the publication of *Select Fables* in 1784, Bewick really showed both his expertise in the art of wood-engraving as a medium for book illustration and his talents as an artist. His engravings for the *History of British Birds* mark the high point of his achievement. The second volume of this work appeared in 1804, the year in which his partnership with Beilby was dissolved.

The essential feature of Bewick’s wood-engravings involved cutting across the grain of the wood instead of along it, as in the old woodcut technique. The wood surface thus obtained offered a much more sensitive medium for engraving than before. It paved the way for the flowering of engraving on wood, and then on steel, for the production of illustrated material for an ever wider public through the Victorian age.

Bibliography

1864, *Memoir of Thomas Bewick* (autobiography, completed by his daughter).

1784, *Select Fables* .

Further Reading

M.Weekley, 1963, *Thomas Bewick*, Oxford: Oxford University Press.

LRD

Beyer, Charles Frederick

- b. 14 May 1813 Plauen, Saxony, Germany
- d. 2 June 1876 Llantysilio, Denbighshire, Wales

*German (naturalized British in 1852) engineer, founder of locomotive builders
Beyer, Peacock & Co.*

Beyer came from a family of poor weavers, but showed talent as an artist and draftsman and was educated at Dresden Polytechnic School. He was sent to England in 1834 to report on improvements in cotton spinning machinery and settled in Manchester, working for the machinery manufacturers Sharp Roberts & Co., initially as a draftsman. When the firm started to build locomotives he moved to this side of the business. The Institution of Mechanical Engineers was founded at his house in 1847. In 1853 Beyer entered into a partnership with Richard Peacock, Locomotive Engineer to the Manchester, Sheffield & Lincolnshire Railway, and Henry Robertson to establish Beyer, Peacock & Co. The company soon established a reputation for soundly designed, elegant locomotives: it exported worldwide, and survived until the 1960s.

Further Reading

Obituary, 1877, *Minutes of Proceedings of the Institution of Civil Engineers* 47.
R.L.Hills, 1967–8 ‘Some contributions to locomotive development by Beyer, Peacock & Co.’, *Transactions of the Newcomen Society* 40 (a good description of Beyer, Peacock & Co’s locomotive work).
See also **Garratt, Herbert William** .

PJGR

Bickford, William

- b. 1774 Devonshire, England
- d. 1834 Tuckingmill, Cornwall, England

English leather merchant, inventor of the safety fuse.

Having tried in vain to make his living as a currier in Truro, Cornwall, he set up as a leather merchant in Tuckingmill and became aware of the high casualty rates suffered by local tin-miners in shot-firing accidents. He therefore started attempts to discover a safe means of igniting charges, and came up with a form of safety fuse that made the operation of blasting much less hazardous. It was patented in 1831 and consisted of a cable of jute and string containing a thin core of powder; it provided a dependable means for conveying the flame to the charge so that the danger of hang fires was almost eliminated. Its accurate and consistent timing allowed the firing of several holes at a time without the fusing of the last being destroyed by the blast from the first. By 1840, a gutta-percha fuse had been developed which could be used in wet conditions and was an improvement until the use of dynamite for shot-firing.

Accounts of the invention, after it had been described in the *Report from the Select Committee on Accidents in Mines* (1835, London) were widespread in various foreign mining journals, and in the 1840s factories were set up in different mining areas on the European continent, in America and in Australia. Bickford himself founded a firm at Tuckingmill in the year that he came up with his invention which was later controlled by his descendants until it finally merged with Imperial Chemical Industries (ICI) after the First World War.

Further Reading

F.Heise, 1904, *Sprengstoffe und Zündung der Sprengschüsse*, Berlin (provides a detailed description of the development).

W.J.Reader, 1970, *Imperial Chemical Industries. A History*, Vol. I, London: Oxford University Press (throws light on the tight international connections of Bickford's firm with Nobel industries).

WK

Bigelow, Erastus Brigham

b. 2 April 1814 West Boyleston, Massachusetts, USA

d. 6 December 1879 USA

American inventor of power looms for making lace and many types of carpets.

Bigelow was born in West Boyleston, Massachusetts, where his father struggled as a farmer, wheelwright, and chairmaker. Before he was 20, Bigelow had many different jobs, among them farm labourer, clerk, violin player and cotton-mill employee. In 1830, he went to Leicester Academy, Massachusetts, but he could not afford to go on to

Harvard. He sought work in Boston, New York and elsewhere, making various inventions.

The most important of his early inventions was the power loom of 1837 for making coach lace. This loom contained all the essential features of his carpet looms, which he developed and patented two years later. He formed the Clinton Company for manufacturing carpets at Leicester, Massachusetts, but the factory became so large that its name was adopted for the town. The next twenty years saw various mechanical discoveries, while his range of looms was extended to cover Brussels, Wilton, tapestry and velvet carpets. Bigelow has been justly described as the originator of every fundamental device in these machines, which were amongst the largest textile machines of their time. The automatic insertion and withdrawal of strong wires with looped ends was the means employed to raise the looped pile of the Brussels carpets, while thinner wires with a knife blade at the end raised and then severed the loops to create the rich Wilton pile. At the Great Exhibition in 1851, it was declared that his looms made better carpets than any from hand looms. He also developed other looms for special materials.

He became a noted American economist, writing two books about tariff problems, advocating that the United States should not abandon its protectionist policies. In 1860 he was narrowly defeated in a Congress election. The following year he was a member of the committee that established the Massachusetts Institute of Technology.

Further Reading

National Cyclopaedia of American Biography III (the standard account of his life).

F.H.Sawyer, 1927, *Clinton Item* (provides a broad background to his life).

C.Singer (ed.), 1958, *A History of Technology*, Vol. V, Oxford: Clarendon Press (describes Bigelow's inventions).

RLH

Biles, Sir John Harvard

b. 1854 Portsmouth, England

d. 27 October 1933 Scotland (?)

English naval architect, academic and successful consultant in the years when British shipbuilding was at its peak.

At the conclusion of his apprenticeship at the Royal Dockyard, Portsmouth, Biles entered the Royal School of Naval Architecture, South Kensington, London; as it was absorbed by the Royal Naval College, he graduated from Greenwich to the Naval Construction Branch, first at Pembroke and later at the Admiralty. From the outset of his professional career it was apparent that he had the intellectual qualities that would enable him to oversee the greatest changes in ship design of all time. He was one of the earliest

proponents of the revolutionary work of the hydrodynamicist William **Froude** .

In 1880 Biles turned to the merchant sector, taking the post of Naval Architect to J. & G. Thomson (later John Brown & Co.). Using Froude's Law of Comparisons he was able to design the record-breaking *City of Paris* of 1887, the ship that started the fabled succession of fast and safe Clyde bank-built North Atlantic liners. For a short spell, before returning to Scotland, Biles worked in Southampton. In 1891 Biles accepted the Chair of Naval Architecture at the University of Glasgow. Working from the campus at Gilmorehill, he was to make the University (the oldest school of engineering in the English-speaking world) renowned in naval architecture. His workload was legendary, but despite this he was admired as an excellent lecturer with cheerful ways which inspired devotion to the Department and the University. During the thirty years of his incumbency of the Chair, he served on most of the important government and international shipping committees, including those that recommended the design of HMS *Dreadnought*, the ordering of the Cunarders *Lusitania* and *Mauretania* and the lifesaving improvements following the *Titanic* disaster. An enquiry into the strength of destroyer hulls followed the loss of HMS *Cobra* and *Viper*, and he published the report on advanced experimental work carried out on HMS *Wolf* by his undergraduates.

In 1906 he became Consultant Naval Architect to the India Office, having already set up his own consultancy organization, which exists today as Sir J.H.Biles and Partners. His writing was prolific, with over twenty-five papers to professional institutions, sundry articles and a two-volume textbook.

Principal Honours and Distinctions

Knighted 1913. Knight Commander of the Indian Empire 1922. Master of the Worshipful Company of Shipwrights 1904.

Bibliography

1905, 'The strength of ships with special reference to experiments and calculations made upon HMS *Wolf*', *Transactions of the Institution of Naval Architects* .
1911, *The Design and Construction of Ships* , London: Griffin.

Further Reading

C.A.Oakley, 1973, *History of a Faculty* , Glasgow University.

FMW

Bilgram, Hugo

b. 13 January 1847 Memmingen, Bavaria, Germany

d. 27 August 1932 Moylan, Pennsylvania, USA

German (naturalized American) mechanical engineer, inventor of bevel-gear generator and economist.

Hugo Bilgram studied mechanical engineering at the Augsburg Maschinenbau Schule and graduated in 1865. He worked as a machinist and draughtsman for several firms in Germany before going to the United States in 1869.

In America he first worked for L.B.Flanders Company and Southwark Foundry & Machine Company in Philadelphia, designing instruments and machines. In the 1870s he also assisted in an evening class in drawing at The Franklin Institute. He devised the Bilgram Valve Diagram for analysing the action of steam engine slide valves and he developed a method of drawing accurate outlines of gear teeth. This led him to design a machine for cutting the teeth of gear wheels, particularly bevel wheels, which he patented in 1884. He was in charge of the American branch of Brehmer Brothers Company from 1879 and in 1884 became the sole owner of the company, which was later incorporated as the Bilgram Machine Works. He was responsible for several other inventions and developments in gear manufacture.

Bilgram was a member of the Franklin Institute, the American Academy of Political and Social Science, the Philadelphia Technische Verein and the Philadelphia Engineer's Club, and was elected a member of the American Society of Mechanical Engineers in 1885. He was also an amateur botanist, keenly interested in microscopic work.

Principal Honours and Distinctions

Franklin Institute Elliott Cresson Gold Medal. City of Philadelphia John Scott Medal.

Bibliography

Hugo Bilgram was granted several patents and was the author of:

1877, *Slide Valve Gears* .

1889, *Involuntary Idleness* .

1914, *The Cause of Business Depression* .

1928, *The Remedy for Overproduction and Unemployment* .

Further Reading

Robert S.Woodbury, 1958, *History of the Gear-cutting Machine* , Cambridge, Mass, (describes Bilgram's bevel-gear generating machine).

RTS

Birdseye, Clarence

b. 9 December 1886 Brooklyn, New York, USA

d. 7 October 1956 USA

American inventor of the fast-freezing method of food preservation.

Clarence Birdseye went to high school at Montclair in New Jersey, and from there to Amherst College between 1906 and 1910. He became a field naturalist on the US Department of Agriculture's survey of 1910 to 1912, and during the following five years worked as a fur trader. He was the Purchasing Agent for the US Navy Corps between 1917 and 1919, and acted as Assistant to the President of the US Fisherman's Association between 1920 and 1922.

Birdseye was a keen fisherman, and during his time in Labrador learnt how to fast-freeze his catch in the wind. He formed the Birdseye Seafood Company in 1923 and pioneered the development of quick-freezing methods for the preservation of dressed seafood. His first company went bankrupt, but he quickly formed the General Seafoods Corporation. He filed his first patent in 1924 for the plate freezer, and in the late 1920s developed the double belt freezer. In 1929 Birdseye's company was bought out for \$22 million, Birdseye himself receiving \$1 million. He was an active member of the American Fisherman's Society, the American Society of Refrigeration Engineers, the American Society of Mechanical Engineers, the American Society of Mammalogists and the Institute of Food Technologists.

Principal Honours and Distinctions

Nutrition Foundation Stephen M. Babcock Award 1949.

Further Reading

W.H. Clark and J. Moynahan, *Famous Leaders of Industry* (gives a brief account of Birdseye's life).

1982, *Frozen Food Age* (August) (an account of the development of the industry he created).

Biringuccio, Vanoccio Vincenzo Agustino Luca

b. 1480 Siena, Italy

d. 1537 Rome, Italy

Italian author of the celebrated 'Pirotechnia' on mining and metallurgy.

Biringuccio spent much of his life in the service of, or under the patronage of, the Petruccis, one of the leading families of Siena. In his youth, he was able to travel widely in Italy and Germany, observing mining and metallurgical processes at first hand. For example, his visit to the brass-works in Milan was to be the source of the detailed description in *Pirotechnia*, published after his death. He held various appointments in charge of mines or other concerns, such as the Siena mint, under the patronage of the Petruccis. During two periods of exile, while the Petrucci fortunes were in eclipse, he engaged in military activities such as the casting of cannon. That included the great culverin of Florence cast in 1529, also described in the *Pirotechnia*. In December 1534 Pope Paul III offered him the post of Director of the papal foundry and munitions. He did not take up the post until 1536, but he died the following year.

Pirotechnia, which made Biringuccio famous, was published in Venice in 1540, three years after his death. The word 'pirotechnia' had a wider meaning than that of fireworks, extending to the action of fire on various substances and including distillation and the preparation of acids. While owing something to earlier written sources, the book is substantially based on a lifetime of practical experience of mining and metalworking, including smelting, casting and alloying, and evidence in the book suggests that it was written between 1530 and 1535. Curzio Navo brought out the second and third editions in 1550 and 1559, as well as a Latin edition. A fourth edition was also printed in 1559. The appearance of four editions in such a short time testifies to the popularity and usefulness of the work.

Bibliography

1942, *Pirotechnia, Translated from the Italian with an Introduction and Notes*, ed. Cyril S. Smith and Martha T. Gnudi, New York: American Institute of Mining and Metallurgical Engineers (the best account of Biringuccio's life, with bibliographical details of the various editions of the *Pirotechnia*, is in the preface).

LRD

Biro, Laszlo Jozsef (Ladislao José)

b. 29 September 1899 Budapest, Hungary

d. 24 October 1985 Buenos Aires, Argentina

Hungarian inventor of the ballpoint pen.

Details of Biro's early life are obscure, but by 1939 he had been active as a painter, a member of the Hungarian Academy of Sciences and an inventor, patenting over thirty minor inventions. During the 1930s he edited a cultural magazine and noticed in the printing shop the advantages of quick-drying ink. He began experimenting with crude ballpoint pens. The idea was not new, for an American, John Loud, had patented a cumbersome form of pen for marking rough surfaces in 1888; it had failed commercially. Biro and his brother Georg patented a ballpoint pen in 1938, although they had not yet perfected a suitable ink or a reservoir to hold it.

In 1940 Biro fled the Nazi occupation of Hungary and settled in Argentina. Two years later, he had developed his pen to the point where he could seek backers for a company to exploit it commercially. His principal backer appears to have been an English accountant, Henry George Martin. In 1944 Martin offered the invention to the US Army Air Force and the British Royal Air Force to overcome the problems aircrews were experiencing at high altitudes with leaking fountain pens. Some 10,000 ballpoints were made for the RAF. Licences were granted in the USA for the manufacture of the 'biro', and in 1944 the Miles-Martin Pen Company was formed in Britain and began making them on a large scale at a factory near Reading, Berkshire; by 1951 its workforce had grown to over 1,000. Other companies followed suit; by varying details of the pen, they avoided infringing the original patents. One such entrepreneur, Miles Reynolds, was the first to put the pen on sale to the public in New York; it is reputed that 10,000 were sold on the first day.

Biro had little taste for commercial exploitation, and by 1947 he had withdrawn from the Argentine company, mainly to resume his painting, in the surrealist style. Examples of his work are exhibited in the Fine Arts Museum in Budapest. He created an instrument that had a greater impact on written communication than any other single invention.

Further Reading

'Nachruf: Ladislao José Biro (1899–1985)', *Historische Burowelt* (1988) 21:5–8 (with English summary).

J.Jewkes, *The Sources of Invention*, pp. 234–5.

LRD

Bi Sheng (Pi Sheng)

- b. c.990 China
- d. c.1051 China

Chinese inventor of movable type for printing.

Bi Sheng was a commoner, 'a man of unofficial position'. The only record of his invention is **Shen Gua**'s writings, the *Meng Qi Bi Tan* (c.1088), which give a clear and complete description of the making of type, typesetting, printing and distribution of the type after printing. Each character was cut in a piece of clay and then baked hard. The type was placed in an iron frame or forme set on an iron plate coated with a sticky resin, wax and paper ash. Printing a few copies was laborious, but for 100 or 1,000 copies the process was relatively quick. Each character had several types, and the commoner ones had as many as twenty or more. No further information about the type has survived, nor has any book produced in this way. Bi Sheng died soon after his invention was made, and so he was probably unable to pass the details on to an apprentice or follower.

Further Reading

Joseph Needham, 1985, *Science and Civilisation in China*, Vol. V(1) Cambridge: Cambridge University Press, vols V(1), pp. 201–3; V(3), p. 187.

LRD

Bissell, George Henry

- b. 8 November 1821 Hanover, New Hampshire, USA
- d. 19 November 1884 New York, USA

American promoter of the petroleum industry.

Bissell first pursued a career in education, as Professor of Languages at the University of Norwich, Vermont, and then as Superintendent of Schools in New Orleans. After dabbling in journalism, he turned to law and was admitted to the Bar in New York City in 1853. The following year he was deeply impressed by the picture of a derrick on the label on a bottle of brine from Samuel M.Kier's brine well. Bissell saw in it a new possibility of producing petroleum and, with Jonathan G.Elveleth, formed the world's first oil company, the Pennsylvania Rock Oil Company, on 30 December 1854. The Company

obtained a sample of oil at Hibbard Farm, Titusville, Pennsylvania, and sent it for examination to Benjamin Silliman Jr, Professor of Chemistry at Yale University. He reported on 16 April 1855 that by simple means nearly all the oil could be converted into useful substances. Bissell acted on this and began drilling near Oil Creek, Pennsylvania. On 27 August 1859 his contractor struck oil at 60 ft (18 m). This date is usually taken as the starting point of the modern oil industry, even though oil had been obtained two years earlier in Europe by drilling near Hannover and at Ploesti in Romania. Bissell returned to New York in 1863 and spent the rest of his life promoting enterprises connected with the oil industry.

Further Reading

Obituary, 1884, *New York Herald*, 20 November.

W.B.Kaempffert, 1924, *A Popular History of American Inventions*, New York.

I.M.Tarbell, 1904, *History of the Standard Oil Company*, New York.

LRD

Black, Harold Stephen

b. 14 April 1898 Leominster, Massachusetts, USA

d. 11 December 1983 Summitt, New Jersey, USA

American electrical engineer who discovered that the application of negative feedback to amplifiers improved their stability and reduced distortion.

Black graduated from Worcester Polytechnic Institute, Massachusetts, in 1921 and joined the Western Electric Company laboratories (later the Bell Telephone Laboratories) in New York City. There he worked on a variety of electronic-communication problems. His major contribution was the discovery in 1927 that the application of negative feedback to an amplifier, whereby a fraction of the output signal is fed back to the input in the opposite phase, not only increases the stability of the amplifier but also has the effect of reducing the magnitude of any distortion introduced by it. This discovery has found wide application in the design of audio hi-fi amplifiers and various control systems, and has also given valuable insight into the way in which many animal control functions operate.

During the Second World War he developed a form of pulse code modulation (PCM) to provide a practicable, secure telephony system for the US Army Signal Corps. From 1963–6, after his retirement from the Bell Labs, he was Principal Research Scientist with General Precision Inc., Little Falls, New Jersey, following which he became an independent consultant in communications. At the time of his death he held over 300 patents.

Principal Honours and Distinctions

Institute of Electronic and Radio Engineers Lamme Medal 1957.

Bibliography

- 1934, 'Stabilised feedback amplifiers', *Electrical Engineering* 53:114 (describes the principles of negative feedback).
 21 December 1937, US patent no. 2,106,671 (for his negative feedback discovery).
 1947, with J.O.Edson, 'Pulse code modulation', *Transactions of the American Institute of Electrical Engineers* 66:895.
 1946, 'A multichannel microwave radio relay system', *Transactions of the American Institute of Electrical Engineers* 65:798.
 1953, *Modulation Theory*, New York: D.van Nostrand.
 1988, *Laboratory Management: Principles & Practice*, New York: Van Nostrand Rheinhold.

Further Reading

For early biographical details see 'Harold S. Black, 1957 Lamme Medalist', *Electrical Engineering* (1958) 77:720; 'H.S.Black', *Institute of Electrical and Electronics Engineers Spectrum* (1977) 54.

See also **Bode**, **Hendrik Wade** ; **Nyquist**, **Harry** .

KF

Blackett, William Cuthbert

b. 18 November 1859 Durham, England

d. 13 June 1935 Durham, England

English mine manager, expert in preventing mine explosions and inventor of a coal-face conveyor.

After leaving Durham college of Physical Science and having been apprenticed in different mines, he received the certificate for colliery managers and subsequently, in 1887, was appointed Manager of all the mines of Charlaw and Sacriston collieries in Durham. He remained in this position for the rest of his working life.

Frequent explosions in mines led him to investigate the causes. He was among the first to recognize the role contributed by coal-dust on mine roads, pioneered the use of inert rock- or stone-dust to render the coal-dust harmless and was the originator of many technical terms on the subject. He contributed many papers on explosion and was

appointed a member of many advisory committees on prevention measures. A liquid-air rescue apparatus, designed by him and patented in 1910, was installed in various parts of the country.

Blackett also developed various new devices in mining machinery. He patented a wire-rope socket which made use of a metal wedge; invented a rotary tippler driven by frictional contact instead of gearing and which stopped automatically; and he designed a revolving cylindrical coal-washer, which also gained interest among German mining engineers. His most important invention, the first successful coal-face conveyor, was patented in 1902. It was driven by compressed air and consisted of a trough running along the length of the race through which ran an endless scraper chain. Thus fillers cast the coal into the trough, and the scraper chain drew it to the main gate to be loaded into trams.

Principal Honours and Distinctions

Knight of Grace of the Order of St John of Jerusalem. OBE. Honorary MSc University of Durham; Honorary LLD University of Birmingham. Honorary Member, Institution of Mining and Metallurgy. Honorary Member, American Institute of Mining and Metallurgical Engineers. Royal Humane Society Medal.

Further Reading

Transactions of the Institution of Mining Engineers (1934–5) 89:339–41.
Mining Association of Great Britain (ed.), 1924, *Historical Review of Coal Mining*
London (describes early mechanical devices for the extraction of coal).

WK

Blanchard, Helen Augusta

b. 25 October 1840 Portland, Maine, USA
d. 1922 USA

American inventor who made improvements in the sewing machine.

Blanchard was the daughter of a wealthy ship owner. She was said to have had inventive talents but seems to have had no technical training. She patented nothing until she was over 30, although that may have been due to shortage of funds. Inheriting the family wealth after the death of her father brought her talents out into the open. She moved to Boston, Massachusetts, and made and patented a number of mechanical devices to improve the sewing machine: these included the ‘over seaming’ machine, a crochet attachment and methods of making knitwear. In 1881, with an unmarried sister, she

founded the Blanchard Overseam Machine Company to exploit her sewing machine inventions. Her company seems to have prospered, for in 1891 she was said to own ‘great estates’, a factory and many patent rights, the returns from which made her a wealthy woman. Patents for sewing machine improvements and attachments continued to flow until 1915. She suffered a stroke in 1916, and died six years later; no will was ever probated, so the fate of her wealth can only be surmised.

Further Reading

A. Stanley, 1993, *Mothers and Daughters of Invention*, Meruchen, NJ: Scarecrow Press, pp. 518–21.

LRD

Blanquart-Evrard, Louis-Desire

b. 2 August 1802 Lille, France

d. 28 April 1872 Lille, France

French photographer, photographic innovator and entrepreneur.

After beginning his working life in a tobacco company, Blanquart-Evrard became Laboratory Assistant to a chemist. He also became interested in painting on ivory and porcelain, foreshadowing a life-long interest in science and art. Following his marriage to the daughter of a textile merchant, Blanquart-Evrard became a partner in the family business in Lyon. During the 1840s he became interested in **Talbot's** calotype process and found that by applying gallic acid alone, as a developing agent after exposure, the exposure time could be shorter and the resulting image clearer. Blanquart-Evrard recognized that his process was well suited to producing positive prints in large numbers. During 1851 and 1852, in association with an artist friend, he became involved in producing quantities of prints for book illustrations. In 1849 he had announced a glass negative process similar to that devised two years earlier by **Niepc de St Victor**. The carrying agent for silver salts was albumen, and more far-reaching was his albumen-coated printing-out paper announced in 1850. Albumen printing paper was widely adopted and the vast majority of photographs made in the nineteenth century were printed in this form. In 1870 Blanquart-Evrard began an association with the pioneer colour photographer **Ducos du Hauron** with a view to opening a three-colour printing establishment. Unfortunately plans were delayed by the Franco-Prussian War, and Blanquart-Evrard died in 1872 before the project could be brought to fruition.

Bibliography

1851, *Traité de photographie sur papier*, Paris (provides details of his improvements to Talbot's process).

Further Reading

J.M.Eder, 1945, *History of Photography*, trans. E. Epstein, New York.

JW

Blenkinsop, John

b. 1783 near Newcastle upon Tyne, England

d. 22 January 1831 Leeds, England

English coal-mine manager who made the first successful commercial use of steam locomotives.

In 1808 Blenkinsop became agent to J.C.Brandling, MP, owner of Middleton Colliery, from which coal was carried to Leeds over the Middle-ton Waggonway. This had been built by Brandling's ancestor Charles Brandling, who in 1758 obtained an Act of Parliament to establish agreements with owners of land over which the wagon way was to pass. That was the first railway Act of Parliament.

By 1808 horse haulage was becoming uneconomic because the price of fodder had increased due to the Napoleonic wars. Brandling probably saw the locomotive *Catch-Me-Who-Can* demonstrated by Richard **Trevithick**. In 1811 Blenkinsop patented drive by cog-wheel and rack rail, the power to be provided preferably by a steam engine. His object was to produce a locomotive able to haul a substantial load, while remaining light enough to minimize damage to rails made from cast iron which, though brittle, was at that date the strongest material from which rails could be made. The wagonway, formerly of wood, was relaid with iron-edge rails; along one side rails cast with rack teeth were laid beside the running surface. Locomotives incorporating Blenkinsop's cog-wheel drive were designed by Matthew **Murray** and built by Fenton Murray & Wood. The design was developed from Trevithick's to include two cylinders, for easier starting and smoother running. The first locomotive was given its first public trial on 24 June 1812, when it successfully hauled eight wagons of coal, on to which fifty spectators climbed. Locomotives of this type entered regular service later in the summer and proved able to haul loads of 110 tons; Trevithick's locomotive of 1804 had managed 25 tons.

Blenkinsop-type locomotives were introduced elsewhere in Britain and in Europe, and those upon the Kenton & Coxlodge Waggonway, near Newcastle upon Tyne, were observed by George **Stephenson**. The Middleton locomotives remained at work until

1835.

Bibliography

10 April, 1811, 'Certain Mechanical Means by which the Conveyance of Coals, Minerals and Other Articles is Facilitated....', British patent no. 3,431.

Further Reading

J.Bushell, 1975, *The World's Oldest Railway*, Sheffield: Turntable (describes Blenkinsop's work).

E.K.Scott (ed.), 1928, *Matthew Murray, Pioneer Engineer*, Leeds.

C.von Oeynhausen and H.von Dechen, 1971, *Railways in England 1826 and 1827*, Cambridge: W.Heffer & Sons.

PJGR

Blériot, Louis

b. 1 July 1872 Cambrai, France

d. 2 August 1936 Paris, France

French aircraft manufacturer and pilot who in 1909 made the first flight across the English Channel in an aeroplane.

Having made a fortune with his patented automobile lamp, Blériot started experimenting with model aircraft in about 1900. He tried a flapping-wing layout which, surprisingly, did fly, but a full-size version was a failure. Blériot tried out a wide variety of designs: a biplane float-glider built with Gabriel **Voisin**; a powered float-plane with ellipsoidal biplane wings; a canard (tail-first) monoplane; a tandem monoplane; and in 1907 a monoplane of conventional layout. This last was not an immediate success, but it led to the *Type XI* in which Blériot made history by flying from France to England on 25 July 1909.

Without a doubt, Blériot was an accomplished pilot and a successful manufacturer of aircraft, but he sometimes employed others as designers (a fact not made known at the time). It is now accepted that much of the credit for the design of the *Type XI* should go to Raymond **Saulnier**, who later made his name with the Morane-Saulnier Company.

Blériot-Aéronautique became one of the leading manufacturers of aircraft and by the outbreak of war in 1914 some eight hundred aircraft had been produced. By 1918, aircraft were being built at the rate of eighteen per day. The Blériot company continued to produce aircraft until it was nationalized in 1937.

Principal Honours and Distinctions

Commandeur de la Légion d'honneur. *Daily Mail* £1,000 prize for the first cross-Channel aeroplane flight.

Further Reading

C.H.Gibbs-Smith, 1965, *The Invention of the Aeroplane 1799–1909*, London (contains a list of all Blériot's early aircraft).

J.Stroud, 1966, *European Transport Aircraft since 1920*, London (for information about Blériot's later aircraft).

For information relating to the cross-Channel flight, see:

C.Fontaine, 1913, *Comment Blériota traversé la Manche*, Paris.

T.D.Crouch, 1982, *Blériot XI, the Story of a Classic Aircraft*, Washington, DC: National Air & Space Museum.

JDS

Blickensderfer, George Canfield

b. 1850 Erie, Pennsylvania, USA

d. 14 August 1917

American maker of the first successful portable typewriter and the first electric typewriter.

Blickensderfer was educated at the academy in Erie and at Allegheny College. He seems to have followed a business career, and in the course of his travels he became aware of the need for a simple, durable, but portable typewriter. He was in business in Stamford, Connecticut, where he developed but did not patent a number of typewriters, including a machine in which a type wheel could print short words such as 'an' and 'as' by depressing a single key. In 1889 he set up the Blickensderfer Manufacturing Company to perfect and mass-produce the machine he had in mind. He needed two years to test and perfect the model, and in 1891 work started on the factory that was to manufacture it. On the verge of mass-production in 1893, he produced a few machines for the Chicago World Exhibition in that year. Their success was sensational, and the 'Blickensderfer' received the highest accolades from the judges, who hailed it as 'extraordinary progress in the art of typewriting'. The 'Blickensderfer' appeared with successive modifications in the following years: they were durable, lightweight machines, with interchangeable type wheels, and were the first widely-used readily-portable typewriters.

Around 1902 Blickensderfer produced the first electric typewriter. A few electric machines were produced and some were sent to Europe, including England, but they are

now very rare. One Blick Electric has been preserved in the Beeching Typewriter Collection in Bournemouth, England.

Further Reading

M.H.Adler, 1973, *The Writing Machine*, London: Allen & Unwin.

Historische Burowelt 10 (July 1985):11 (provides brief biographical details in German with an English summary).

LRD

Blith, Walter

b. Seventeenth century Warwickshire, England

d. Seventeenth century England

English farmer and agricultural writer

Blith was the son of a cereal and dairy farmer from the Forest of Arden. He wrote a treatise on farming which was of contemporary value in its description of drainage and water meadows, both subjects of particular relevance in the mid-seventeenth century. The book, *The English Improver*, contains illustrations of agricultural equipment which have become an almost obligatory inclusion in any book on agricultural history. His understanding of the plough is apparent from the text and illustrations, and his was an important step in the understanding of the scientific principles to be applied to its later design. The introduction to the book is addressed to both Houses of Parliament, and is very much an attempt to highlight and seek solutions to the problems of the agriculture of the day. In it he advocates the passing of legislation to improve agricultural practice, whether this be for the destruction of moles or for the compulsory planting of trees to replace those felled.

Blith himself became a captain in the Roundhead Army during the English Civil War, and even added a dedication to Cromwell in the introduction to his second book, *The English Improver Improved*, published in 1652. This book contains additional information on both practice and crops, an expansion in knowledge which presumably owes something to Blith's employment as a surveyor of Crown lands between 1649 and 1650. He himself bought and farmed such land in Northamptonshire. His advice on the choice of land for particular crops and the implements of best use for that land expressed ideas in advance of their times, and it was to be almost a century before his writings were taken up and developed.

Bibliography

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Further Reading

- J.Thirsk (ed.), 1985, *The Agrarian History of England and Wales* , Vol. II (deals with Blith and the agriculture of his time).

AP

Bloch, Jacob

fl.1888

European inventor of a machine for cutting layers of cloth.

In mass production of garments, layers of cloth are laid out on top of each other and multiples of each different part are cut out at the same time. The first portable cutting machine was invented by Joseph Bloch in 1888. It was operated from a DC electricity supply and had a circular knife, which was difficult to use when cutting round curves. Therefore the cloth had to be raised on curves so that it would reach the furthest part of the circular blade. In the same year in the USA, G.P.Eastman produced a vertically reciprocating cutting machine with a straight blade.

Further Reading

- C.Singer (ed.), 1978, *A History of Technology* , Vol. VI, Oxford: Clarendon Press (describes Bloch's invention).
I.McNeil (ed.), 1990, *An Encyclopaedia of the History of Technology* , London: Routledge, pp. 850–2 (provides a brief description of the making-up trade).
D.Sinclair, 'The current climate for research and development in the European-clothing industry with particular reference to single ply cutting?', unpublished MSc thesis, Salford University (discusses developments in garment production).

RLH

Bloch, Marcel

See **Dassault, Marcel** .

Blumlein, Alan Dower

b. 29 June 1903 Hampstead, London, England

d. 7 June 1942

English electronics engineer, developer of telephone equipment, highly linear electromechanical recording and reproduction equipment, stereo techniques, video and radar technology.

He was a very bright scholar and received a BSc in electrical technology from City and Guilds College in 1923. He joined International Western Electric (later to become Standard Telephone and Cables) in 1924 after a period as an instructor/demonstrator at City and Guilds. He was instrumental in the design of telephone measuring equipment and in international committee work for standards for long-distance telephony.

From 1929 Blumlein was employed by the Columbia Graphophone Company to develop an electric recording cutterhead that would be independent of Western Electric's patents for the system developed by **Maxfield** and Harrison. He attacked the problems in a most systematic fashion, and within a year he had developed a moving-coil cutterhead that was much more linear than the iron-cored systems known at the time. Eventually Blumlein designed a complete line of recording equipment, from microphone and through-power amplifiers. The design was used by Columbia; after the merger with the Gramophone Company in 1931 to form Electrical and Musical Industries Ltd (later known as EMI) it became the company standard, certainly for coarse-groove records, until c.1950.

Blumlein became interested in stereophony (binaural sound), and developed and demonstrated a complete line of equipment, from correctly placed microphones via two-channel records and stereo pick-ups to correctly placed loudspeakers. The advent of silent surfaces of vinyl records made this approach commercial from the late 1950s. His approach was independent and quite different from that of A.C. **Keller** .

His extreme facility for creating innovative solutions to electronic problems was used in EMI's development from 1934 to 1938 of the electronic television system, which became the BBC standard of 405 lines after the Second World War, when television broadcasting again became possible. Independent of official requirements, EMI developed a 60 MHz radar system and Blumlein was involved in the development of a centimetric radar and display system. It was during testing of this aircraft mounted

equipment that he was killed in a crash.

Bibliography

Blumlein was inventor or co-inventor of well over 120 patents, a complete list of which is to be found in Burns (1992; see below). The major sound-recording achievements are documented by British patent nos. 350,954, 350,998, 363,627 (highly linear cutterhead, 1930) and 394,325 (reads like a textbook on stereo technology, 1931).

Further Reading

The definitive biography of Blumlein has not yet been written; the material seems to have been collected, but is not yet available. However, R.W.Burns, 1992, 'A.D.Blumlein, engineer extraordinary', *Engineering Science and Education Journal* (February): 19–33 is a thorough account. Also B.J.Benzimra, 1967, 'A.D. Blumlein: an electronics genius', *Electronics & Power* (June): 218–24 provides an interesting summary.

GB-N

Bode, Hendrik Wade

b. 24 December 1905 Madison, Wisconsin, USA

d. 21 June 1982 Cambridge, Massachusetts, USA

American engineer who developed an extensive theoretical understanding of the behaviour of electronic circuits.

Bode received his bachelor's and master's degrees from Ohio State University in 1924 and 1926, respectively, and his PhD from Columbia University, New York, in 1935. In 1926 he joined the Bell Telephone Laboratories, where he made many theoretical contributions to the understanding of the behaviour of electronic circuits and, in particular, in conjunction with Harry **Nyquist**, of the conditions under which amplifier circuits become unstable.

During the Second World War he worked on the design of gun control systems and afterwards was a member of a team that worked with **Douglas** Aircraft to develop the Nike anti-aircraft missile. A member of the Bell Laboratories Mathematical Research Group from 1929, he became its Director in 1952, and then Director of Physical Sciences. Finally he became Vice-President of the Laboratories, with responsibility for systems engineering, and a director of Bellcomm, a Bell company involved in the Moon-landing programme. When he retired from Bell in 1967, he became Professor of Systems Engineering at Harvard University.

Principal Honours and Distinctions

Presidential Certificate of Merit 1946. Institute of Electrical and Electronics Engineers
Edison Medal 1969.

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1945, *Network Analysis and Feedback Amplifier Design*, New York: Van Nostrand.
1950, with C.E.Shannon, 'A simplified derivation of linear least squares smoothing and prediction theory', *Proceedings of the Institute of Radio Engineers* 38:417.
1961, 'Feedback. The history of an idea', *Proceedings of the Symposium on Active Networks and Feedback Systems*, Brooklyn Polytechnic.
1971, *Synergy: Technical Integration and Technical Innovation in the Bell System Bell Laboratories*, Bell Telephone Laboratories (provides background on his activities at Bell).

Further Reading

P.C.Mahon, 1975, *Mission Communications*, Bell Telephone Laboratories.
See also **Black, Harold Stephen ; Shannon, Claude Elwood** .

KF

Bodmer, Johann Georg

b. 9 December 1786 Zurich, Switzerland
d. 30 May 1864 Zurich, Switzerland

Swiss mechanical engineer and inventor.

John George Bodmer (as he was known in England) showed signs of great inventive ability even as a child. Soon after completing his apprenticeship to a local millwright, he set up his own work-shop at Zussnacht. One of his first inventions, in 1805, was a shell which exploded on impact. Soon after this he went into partnership with Baron d'Eichthal to establish a cotton mill at St Blaise in the Black Forest. Bodmer designed the water-wheels and all the machinery. A few years later they established a factory for firearms and Bodmer designed special machine tools and developed a system of interchangeable manufacture comparable with American developments at that time. More inventions followed, including a detachable bayonet for breech-loading rifles and a rifled, breech-loading cannon for 12 lb (5.4 kg) shells.

Bodmer was appointed by the Grand Duke of Baden to the posts of Director General of the Government Iron Works and Inspector of Artillery. He left St Blaise in 1816 and entered completely into the service of the Grand Duke, but before taking up his duties he visited Britain for the first time and made an intensive five-month tour of textile mills, iron works, workshops and similar establishments.

In 1821 he returned to Switzerland and was engaged in setting up cotton mills and other engineering works. In 1824 he went back to England, where he obtained a patent for his improvements in cotton machinery and set up a mill near Bolton incorporating his ideas. His health failing, he was obliged to return to Switzerland in 1828, but he was soon busy with engineering works there and in France. In 1833 he went to England again, first to Bolton and four years later to Manchester in partnership with H.H. Birley. In the next ten years he patented many more inventions in the fields of textile machinery, steam engines and machine tools. These included a balanced steam engine, a mechanical stoker, steam engine valve gear, gear-cutting machines and a circular planer or vertical lathe, anticipating machines of this type later developed in America by E.P. **Bullard**. The metric system was used in his workshops and in gearing calculations he introduced the concept of diametral pitch, which then became known as 'Manchester Pitch'. The balanced engine was built in stationary form and in two locomotives, but although their running was remarkably smooth the additional complication prevented their wider use.

After the death of H.H. Birley in 1846, Bodmer removed to London until 1848, when he went to Austria. About 1860 he returned to his native town of Zurich. He remained actively engaged in all kinds of inventions up to the end of his life. He obtained fourteen British patents, each of which describes many inventions; two of these patents were extended beyond the normal duration of fourteen years. Two others were obtained on his behalf, one by his brother James in 1813 for his cannon and one relating to railways by Charles Fox in 1847. Many of his inventions had little direct influence but anticipated much later developments. His ideas were sound and some of his engines and machine tools were in use for over sixty years. He was elected a Member of the Institution of Civil Engineers in 1835.

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