BARON JEAN BAPTISTE JOSEPH FOURIER

1768-1830

French mathematician and physicist famous for his pioneer work on the representation of functions by trigonometric series, was born at Auxere on March 21, 1768, the son of a tailor. He became a teacher in mathematics in 1784 at the military school there. He taught at the Ecole Normale at Paris from its founding in 1795, where his success soon led to the offer of the chair of analysis at the Ecole Polytechnique. In 1807 he was made a member of the academy of sciences.

Fourier's masterpiece was his mathematical theory of heat conduction stated in "Theorie Analytique de la Chaleur" (1822), one of the most important books published in the 19th century. It marked an epoch both in the history of pure and of applied mathematics, for in it Fourier developed the theory of the series known by his name and applied it to the solution of boundary-value problems in partial differential equations. This work brought to a close a long controversy, and henceforth it was generally agreed that almost any function of a real variable can be represented by a series involving the sines and cosines of integral multiples of the variable. Fourier died in Paris on May 16, 1830.

$$Fo = \frac{\alpha \cdot t}{L^2}$$

JEAN BAPTISTE BIOT

1774-1862

French physicist, best known for his work in polarization of light, was born in Paris on April 21, 1774. In 1800 he became professor of phsysics at the College de France, through the influence of Laplace, from whom he had sought and obtained the favour of reading the proof sheets of the "Mecanique Celeste".

J. B. Biot, although younger than Fourier, worked on the analysis of heat conduction even earlier - in 1802 or 1803. He attempted, unsuccessfully, to deal with the problem of incorporating external convection effects in heat conduction analysis in 1804. Fourier read Biot's work and by 1807 had determined how to solve the problem.

In 1804 he accompanied Gay Lusac on the first balloon ascent undertaken for scientific purposes, in 1820, with Felix Savart, he discovered the law known as "Biot and Savart's Law". He was especially interested in questions relating to the polarization of light, and for his achievements in this field he was awarded the Rumford Medal of the Royal Society in 1840. He died in Paris on February 3, 1862.

$$Bi = \frac{h \cdot L}{k_s}$$

JEAN CLAUDE EUGENE PECLET

1793-1857

$$Pe = \frac{v \cdot L}{a} = Re \cdot Pr$$

French physicist, born February 10, 1793 at Besancon, became one of the first scholars of the Ecole Normale at Paris, Gay Lussac and Dulong being his teachers. Peclet was elected professor at the College de Marseille in 1816, teaching physical sciences there until 1827. He returned to Paris when nominated Maitre de Conferences at the Ecole Normale and was elected professor at the important Ecole Centrale des Arts et Manufactures. In 1840 he became Inspecteur General de L'Instruction Publique and retired from this charge in 1852 to devote himself exclusively to teaching.

His publications were famous for their clarity of style, sharpminded views and well performed experiments. His famous book "Traite de la Chaleur et de ses Applications aux Arts et Aux Manufactures" (Paris 1829) was distributed world-wide and had been translated in German.

Peclet continued lecturing until his death December 6, 1857 at Paris.

FRANZ GRASHOF

1826-1893

German engineer, born July 11, 1826 at Düsseldorf, left school at the age of 15 to work as a mechanic, and then attended trade school in Hage and secondary school in Düsseldorf. From 1844 until 1847 Grashof studied mathematics, physics and machine design at the Berlin Royal Technical Institute. After a voyage of nearly three years which took him as far as the Dutch Indies and Australia he continued his studiesat Berlin in 1852.

$$Gr = \frac{g \cdot \beta \cdot \Delta T \cdot L^3}{v^2}$$

Grashof was one of the leaders in founding the Society of German Engineers (Verein Deutscher Ingenieure, VDI) and assumed an enormous load as author, editor, corrector and dispatcher. In 1863 Redtenbacher died and Grashof's name was so esteemed that the Technical University of Karlsruhe appointed him to be successor as superindependent of the engineering school. He also served as professor of applied mechanics and mechanical engineering and his lectures included strength of materials, hydraulics and theory of heat, in addition to general engineering.

After Grashof's death, October 26, 1893 at Karlsruhe the Society of German Engineers honored his memory by the institution of the Grashof Commemorative Medal as the highest distinction that the society could bestow for merit in the engineering skills.

JOSEF STEFAN

1835-1893

Austrian physicist, whose original contributions ranged over several important fields, including the kinetic theory of gases, hydrodynamics and in particular, radiation, was born on March 24, 1835 at St. Peter near Klagenfurt and died on January 7, 1893 in Wien.

$$Sf = \frac{h_{f,s}}{c_s \left(T_{melt} - T_{\infty}\right)}$$

Stefan was educated at the University of Wien, receiving his doctor of philosophy in 1858, then became privatdozent in mathematical physics, in 1863 professor ordinarius of physics and in 1866 director of the physical institute. He was a distinguished member of the Academy of Sciences of Wien, of which he was appointed secretary in 1875. Before Stefan's work, G. R. Kirchhoff had already described the perfect radiator as the "Perfect Black Body", namely, one that absorbed all the radiation that fell on it and reflected none, but emitted radiation of all wave lengths. Stefan showed empirically in 1879 that the radiation of such a body was proportional to the fourth power of its absolute temperatures, a relationship known as the "Stefan & Boltzmann" law after it had been deduced by L. Boltzmann in 1884 from thermodynamic considerations.

In the year 1891 Stefan published his work on the formation of ice in the polar seas, giving a special solution of this nonlinear conduction problem with phase change (the more general solution being due to F. Neumann).

ERNST MACH

1838-1916

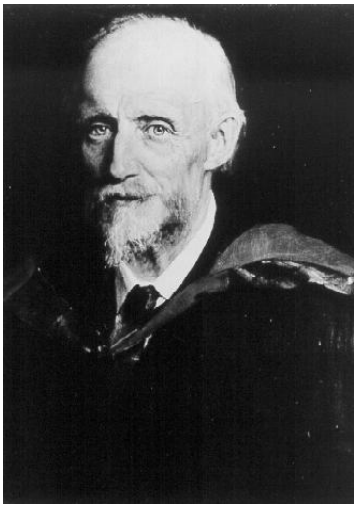
Austrian physicist and philosopher, whose work, both in physics and in philosophy, had a great influence on 20th-century thought, was born on February 18, 1838, at Turas in Moravia and educated in Wien. He was professor of physics at Graz from 1864 to 1867 and at Prag from from 1867 to 1895, and professor of inductive philosophy at Wien from 1895 to 1901. He was made a member of the Austrian House of Peers in 1901 and died at München on February 19, 1916.

$$Ma = \frac{v}{v_{Sound}}$$

Mach was a throughgoing positivist and took the view, which most scientists now share, that no statement is admissible in natural science unless it is empirically verifiable. His criteria of verifiability were, however exceptionally rigorous: They led him not only to reject such metephysical conceptions but also to oppose the introduction of atoms and molecules into the physical theory. Nevertheless it was his criticism along the lines of Sir Isaac Newton's system that made the way clear for Albert Einstein's theory of relativity. As a positivist, he regarded scientific laws as purely descriptive; and he held that the choice between the alternative hypotheses covering the same facts was to be made on the grounds of economy. Mach's name is associated with the Mach Number, which expresses the speed of matter relative to the local speed of sound.

OSBOURNE REYNOLDS

1842-1912



English engineer and physicist, best known for his work in the field of hydraulics and hydrodynamics, was born at Belfast on Aug. 23, 1842. Gaining early workshop experience and graduating at Queens' College Cambridge in 1867, he became the first professor of engineering in the Owens College, Manchester in 1868. He was elected a fellow of the Royal Society in 1877 and a Royal Medallist in 1888.

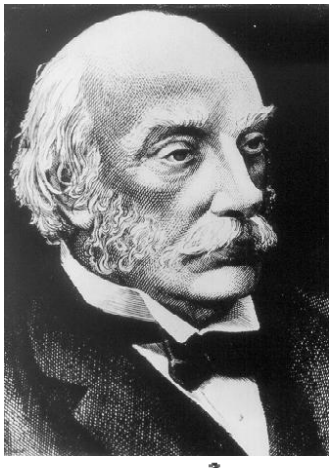
Reynolds' studies of condensation and the transfer of heat between solids and fluids brought radical revision in boiler and condenser design, while his work on turbine pumps laid the foundation of their rapid development. A fundementalist among engineers, he formulated the theory of lubrication (1886), and in his classical paper on the law of resistance in parallel channels (1883) investigated the transition from smooth, or laminar, to turbulent flow, later (1889) developing the mathematical framework which became standard in turbulence work.

$$Re = \frac{v \cdot L}{\nu}$$

His name is perpetuated in the "Reynolds Number", which provides a criterion for dynamic similarity and hence for correct modelling in many fluid flow experiments.

Reynolds retired in 1905 and died at Watchet, Somerset, on Feb. 21, 1912.

LORD RAYLEIGH



$$Ra = \frac{g \cdot \beta \cdot \Delta T \cdot L^3}{\nu \cdot \alpha} = Gr \cdot Pr$$

1842-1919

British physicist, who was awarded the Nobel Prize for physics in 1904 for his discovery (1894) of the inert elementary gas Argon, in collaboration with Sir William Ramsay, was born near Maldon, Essex, on Nov. 12, 1842, and educated at Trinity College, Cambridge, where he graduated senior Wrangler (1865). As successor to James Clerk Maxwell he was head of the Cavendish Laboraty at Cambridge from 1879 to 1884, and in 1887 he became professor of Natural Philosophy in the Royal Institution of Great Britain. Elected (1873) a fellow of the Royal Society, he was president from 1905 to 1908.

His research almost covered the entire field of physics, including sound, wave theory, optics, colour vision, electrodynamics, electromagnetism, the scattering of light, hydrodynamics, the flow of liquids, capillary, viscosity, the density of gases, photgraphy and elasticity, as well as electrical measurements and standards. His research on sound was embodied in his "Theory of Sound", and his other extensive studies in physics appeared in his "Scientific Papers". Rayleigh died on June 30, 1919 at Witham, Essex.

LEO GRAETZ

1856-1941

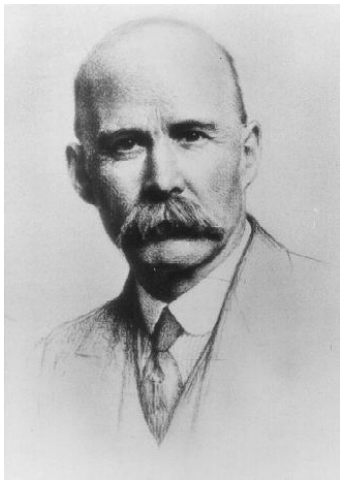
German physicist, born at Breslau on September 26, 1856, studied mathematics and physics at Breslau, Berlin and Strassburg. In 1881 he became assistant to A. Kundt at Strassburg and in 1883 he went to the University of München, where he became a professor in 1908 and occupied the Second Chair for physics parallel to roentgen.

His scientific work was first concerned with the fields of heat conduction, radiation, friction and elasticity and after 1890 with problems of electromagnetic waves and cathode rays.

$$Gz = \frac{v \cdot D^2}{a \cdot L} = \frac{Re_D \cdot Pr \cdot D}{L}$$

Graetz was a profilic technical writer, with 23 editions of his "Electricity and its Applications" and a five volume work "Handbook of Electricity and Magnetism", which contributed to the wide dissemination of knowledge in electricity, which at that time was in its infancy. He died in München on November 12, 1941.

SIR THOMAS EDWARD STANTON



$$St = \frac{h}{\rho \cdot c_p \cdot v} = \frac{Nu}{Re \cdot Pr}$$

1865-1931

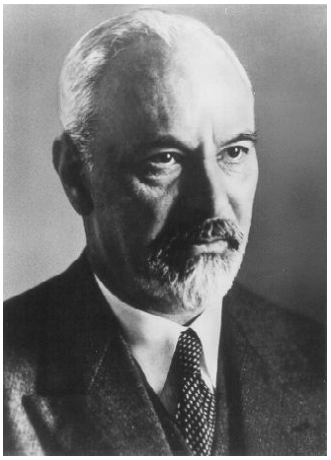
British engineer, born at Atherstone in Warwickshire on December 12, 1865. In 1888 he entered Owens College, Manchester, and followed the engineering course in the Whitworth Laboratory under Osborne Reynolds. After taking the degree of B.Sc. in 1891 at the Victoria University, with First-Class Honours, he continued to work in Reynolds' laboratory, at first as junior and later as senior demonstrater, until 1896. From 1892 to 1896 he was also resident tutor in mathematics and engineering at the Hulme Hall of Residence, Manchester. In June, 1896, Stanton obtained a post as senior assistant lecturer in engineering at University College, Liverpool, under professor Hele-Shaw. In December, 1899, he went from Liverpool to Bristol University College as professor engineering.

In July, 1901, he was offered the position of superintendent of the Engineering Department of the National Physical Laboratory in Bristol. This post he continued to hold until his retirement from official duties in December, 1930, at the age of 65, one year before his death.

Stanton's main field of interest was fluid flow and friction, and the related problem of heat transmission, from 1902 to 1907 he excuted a large research program concerning wind forces on structures, such as bridges and roofs. After 1908, the year when the Wright Brothers made their first aeroplane flights in Europe, Stanton devoted to problems of aeroplane and airship design and the dissipation of heat from air-cooled engines.

LUDWIG PRANDTL

1875-1953



$$Pr = \frac{\nu}{\alpha}$$

German physicist famous for his work in aeronautics, was born at Freising, Bavaria, on February 4, 1875. He qualified at München in 1900 with a thesis on elastic stability, and was professor of applied mechanics at Göttingen from 1904 until his death there on August 15, 1953. In 1925 he became director of The Kaiser Wilhelm Institute for Fluid Mechanics. His discovery (1904) of the "Boundary Layer" which adjoins the surface of a body moving in a fluid led to an understanding of skin friction drag and of the way in which streamliningreduces the drag of airplane wings and other moving bodies. His work on wing theory, published in 1918-1919, which followed that of F.W. Lanchester (1902-1907) but was carried out independently. elucidated the flow over plane wings of finite span.

Prandtl made decisive advances in boundary layer and wing theories, and his work became the basic material of aeronautics. He also made important contributions to the theories of supersonic flow and of turbulence, besides contributing much to the development of wind tunnels and other aerodynamic equipment. In addition, he devised the soap-film analogy for the torsion of noncircular sections and wrote on the theory of plasticity and of meteorology.

MAX JAKOB

1879-1955

$$Ja = \frac{c_{p,f}\left(T_{wall} - T_{sat}\right)}{h_{f\,g}}$$

German physicist, born July 20, 1879 in Ludwigshafen, studied electrical engineering at the Technical University of München where he graduated in 1903. From 1903 until 1906 he was an assistant to O. Knoblauch at the Laboratory for Technical Physics. After working in the electrical industry Jakob joined the "Physikalisch-Technische Reichsanstalt" at Berlin-Charlottenburg in 1910, where he started his career in thermodynamics and heat transfer. He conducted a large amount of important works in these fields, covering such areas as steam and air at high pressure, devices for measuring thermal conductivity, the mechanisms of boiling and condensation, flow in pipes and nozzles, and others.

In 1936 he emigrated to the United States, where he became a research professor at the Illinois Institute of Technology and consultant in Heat Transfer for the Armour Research Foundation. In 1952, three years before his sudden death, he was awarded the Worchester Reed Warner Medal by the American Society of Mechanical Engineers.

His long years of research resulted in significant contributions to the literature of the profession; nearly 500 books, articles, reviews and discussions have been published.

WILHELM NUSSELT

1882-1957

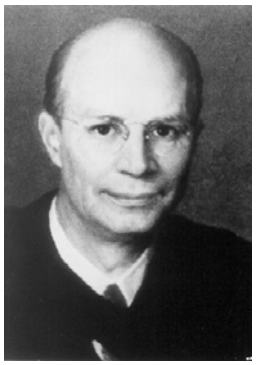
German engineer, born November 25, 1882 at Nürnberg, studied machinery at the Technical Universities of Berlin-Charlottenburg and München where he graduated in 1904 and conducted advanced studies in mathematics and physics. He became an assistant to O. Knoblauch at the Laboratory for Technical Physics in München and completed his doctoral thesis on the conductivity of insulating materials in 1907, using the "Nusselt Sphere" for his experiments. From 1907 to 1909 he worked as an assistant of Mollier in Dresden, qualifying himself for a professorship with a work on heat and momentum transfer in tubes.

$$Nu = \frac{h \cdot L}{k_f}$$

In 1915 Nusselt published his pioneer paper: "The Basic Laws of Heat Transfer" in which he first proposed the dimensionless groups now known as the principal parameters in the similarity theory of heat transfer. Other famous works were concerned with the film condensation of steam on vertical surfaces, the combustion of pulverized coal and the analogy between heat and mass transfer in evaporation. Among the primarily mathematical works of Nusselt, the well known solutions for laminar heat transfer in the entrance region of tubes, for heat exchange in cross-flow and the basic theory of regenerators should be mentioned.

Nusselt was professor at the Technical Universities of Karlsruhe from 1920 to 1925 and at München from 1925 until his retirement in 1952. He was awarded the Gauss-Medal and the Grashof Commemorative Medal. Nusselt died in München on September1, 1957.

ALLAN PHILIP COLBURN



$$j = St \cdot Pr^{2/3} = \frac{Nu}{Re \cdot Pr^{1/3}}$$

1904-1955

American Engineer, born in Madison, Wisconsin, on june 8, 1904 graduated from the University of Wisconsin in Chemical Engineering with high honors in 1926 and was awarded an engineering fellowship for graduate studies. He received his Master of Science in 1927 and his Ph.D. in 1929.

His research was on condensation of water vapor from saturated air streams, a topic that in its broader aspects interested him to the end of his life. He brought together for the first time in American engineering work the fundamentals of momentum, heat and mass transfer along with thermodynamic principles to deal with this complex problem.

Although not known formally, perhaps, as a dimensionless parameter, the empirical Colburn J-Factor is indeed an operational one.

Colburn joined the Chemical Engineering Department at the University of Delaware in 1938. He was appointed as assistant to the President of the University in 1947, Acting President in 1950 and Provost and Coordinator of Scientific Research until his death in 1955.

ERNST SCHMIDT

$$Sc = \frac{\nu}{D_{AB}}$$

1892-1975

German scientist and pioneer in the field of engineering thermodynamics, especially in heat and mass transfer, was born on February 11, 1892 at Vögelsen, near Lüneburg. He studied civil and electrical engineering at Dresden and München, and joined the Laboratory for Applied Physics at the Tchnical University, München, in 1919, which was then under the direction of Oscar Knoblauch. One of his early research efforts there was a careful measurement of the radiation properties of solids, which caused him to propose and develop the use of aluminium foil as an effective radiation shield.

In 1925 he received a call to come as professor and director of the Engineering Laboratory to the Technical University, Danzig. Here he published papers on the now well known graphical difference method for unsteady heat conduction, and on the Schlieren and Shadow method to make thermal boundaries visible and to obtain local heat transfer coefficients. He was the first to measure the velocity and temperature field in a free convection boundary layer and the large heat transfer coefficients occuring in droplet condensaton. A paper pointing out the analogy between heat and mass transfer caused the dimensionless quantity involved to be called "Schmidt Number". In 1937 he became director of the Institute for Propulsion of the newly founded Aeronautical Research Establishment at Braunschweig and professor at the University there. In 1952 Schmidt occupied the chair for thermodynamics at the Technical University of München which before him had been held by Nusselt. Being strongly involved in the development of the international steam tables, Schmidt continued his scientific activity after his retirement (1961) until his death in 1975.

THOMAS KILGORE SHERWOOD

1903-1976

$$Sh = \frac{k_{Mass} \cdot L}{k_f}$$

Sherwood, born in Columbus, Ohio, July 25, 1903, was one of America's great chemical engineers; his energy, research contributions, applied engineering achievements, and influence on chemical engineering education were prodigious. Sherwood came to M.I.T. in 1923 for graduate work in the Chemical Engineering Department and completed his doctoral thesis under Warren K. Lewis. entitled "The Mechanism of the Drying of Solids" in 1929. From 1930 to 1969 he was professor at M.I.T. contributing decisively to the standards of excellence of this famous institution.

Sherwood's primary research area was mass transfer and its interaction with flow and with chemical reaction and industrial process operations in which those phenomena played an important part. His rapid rise to the position of world authority in the field of mass transfer was accelerated by the appearence of his book, "Absorption and Extraction", the first significant text in this area, published in 1937. Completely rewritten, with Pigford and Wilke in 1974 under the title "Mass Transfer", the book has had enormous influence. The worldwide use of the Sherwood Number is a memorial to that effort .

In addition to three honorary doctorates many awards were bestowed on Sherwood, such as the U.S. Medal for Merit in 1948 and the Lewis Award in 1972. He died on January 14, 1976.