Fluid mechanics

G.I. Taylor and his influence

from Herbert E. Huppert

SIR Geoffrey Ingram Taylor OM, FRS was one of the giants of physical science in this century. His work was at the centre of research on the mechanics of fluids and solids and their application to aeronautics, chemical engineering, meteorology, mechanical engineering, metal physics and oceanography. He had a distinctive style of research that brought penetrating insight into the fundamental nature of almost all the problems he considered. At the same time, he was generally able to

Sir Geoffrey Taylor investigating the motion of a fluid in a partially filled spinning cylinder.

design simple but effective laboratory experiments that tested, and usually confirmed, his theoretical concepts. Taylor was born on 7 March 1886 and, at a recent meeting* to celebrate the centenary of his birth, it was asked whether the style of his work is still alive, and of value, to contemporary research workers.

Taylor liked to describe himself as an amateur scientist — by which he meant that he enjoyed working independently, with a minimum of help from others, and, of central importance, for pleasure. His scientific curiosity led him frequently to initiate new areas of research, only to lose interest in them after he had discovered the fundamental phenomena of one field, by which time the possibility of developing another novel field struck his imagination. After the tragic sinking of the Titanic in 1912, Taylor was invited to be the meteorologist on the old sailing ship Scotia, which had been requisitioned to investigate the motion of icebergs in the North Atlantic. While on board, he grasped the opportunity to design instruments attached to balloons and kites flown to heights of 2 km from the masthead of the ship. From these instruments, Taylor obtained the first reliable estimates of the transfer rates of momentum, heat and water vapour in the lower atmosphere. This work consolidated his interest in meteorology and turbulent diffusion and dispersion, to which he contributed so much in later years.

Taylor also originated important ideas in solid mechanics. A series of definitive experiments on various materials led him to develop a theory for 'dislocations' in metal crystals which predicted how cracks propagate and accounted for the observed strength of metal crystals. Motivated by conversations with Lord Rothschild, Taylor initiated the quantitative study of the swimming of microorganisms and, on the way, constructed a model of the tail of a spermatozoon from a metal-wire helix enclosed in a rubber sheath. The sheath rotated by the action of a wound-up rubber band anchored inside a head at one end of the helix. This model swam through glycerine at a rate that agreed with Taylor's theoretical prediction.

Because of the wide-ranging applicability of fluid and solid mechanics, and because of Taylor's ingenuity, his abilities were called on during the two world wars. In 1914 he helped to investigate the design and operation of military airplanes. While doing so he learnt to fly and make parachute jumps; operating as both experimenter and pilot he made the first pressure measurements over a wing in steady flight. During World War II he analysed and advised on a wide range of problems, including the rate of propagation of blast waves emanating from intense explosions.

Taylor produced more than 200 scientific papers spanning the years from 1909 to 1972. An example of his inventiveness occurs in his design of an anchor. Unhappy with the holding power and weight of the traditional anchor, Taylor created a totally new design, with a single hook shaped like a double-bladed, symmetrical plough-share. This was much lighter than traditional anchors yet had the same holding power. These 'CQR' anchors are now widely used in small vessels and are still the best available.

Is it still possible, and useful, to carry out current research in the style of G.I. Taylor? He used his intuition and just sufficient mathematics and experimentation to develop extraordinary insight into the general nature of the area being considered. As was clear from the recent meeting, this style, although not easy to imitate, is currently being used to good effect in several areas of fluid mechanics. The conference confirmed that current research in fluid mechanics, in contrast to some other subjects, permits important contributions to be made on a very broad range of problems. These include dynamical problems such as chaotic and turbulent behaviour in the atmosphere and oceans and in industrial contexts. Another important area concerns the formation of 'finger' patterns when fluid of one viscosity displaces fluid of another within a confined space — a subject also started by Taylor, who wanted to understand how oil could be recovered from porous rock by driving it up ahead of a heavier, less viscous water layer pumped into the base of the rock. Such questions continue to demand all the imagination and ingenuity of Taylor's successors and will be solved by individual scientists or small groups working on their own — and for pleasure. □

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Catalysis

Designing porous solids

from John M. Thomas

A JET of hydrogen impinging in air on platinized, fibrous asbestos produces a spark. The famous nineteenth century German chemist, Döbereiner, capitalized on this phenomenon in the first commercial exploitation of heterogeneous catalysis. More than a million tinder boxes, containing compartments housing zinc and acid to generate the hydrogen, were made in the late 1820s and used as fire-lighting devices. The key to their operation is the degree of subdivision of the platinum engendered by the exceptionally large area of the fibrous support: no sparks are produced with platinum wires, rods or foils of low area. Chemists ever since have been seeking new large-area solids, especially those that function as synergistic catalysts with a supported metal — such as rhodium for the control of automobile emissions, or palladium for the production of many pharmaceuticals. But industrial catalysis is not the only driving force in this quest. Porous solids are also required as platforms for a range of immobilized enzymes, as improved columns in adsorption and ion-exchange chromatography, and for effecting gas separations such as meth-

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