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(*b*. Belfast, Ireland, 23 August 1842; *d*. Somerest, England, 21 February 1912)

engineering, physics.

Reynolds's was born into an Anglican clerical family. His father-like his grandfather and great-grandfather before him was rector of Debatch-with- Boulge in addition to having been a Cambridge wrangler in 1837, a fellow of Queen's College, principal of the Belfast Collegiate School, and headmaster of Dedham Grammer School, Essex.

Reynolds was educated first at Dedham and then privately before entering the service of Edward Hayes, a mechanical engineer, in 1861. He did an apprenticeship with Hayes in order to learn the mechanical arts before going like his father to Cambridge and eventually onto a career in civil engineering. "In my boyhood", Reynolds later wrote, "I had the advantage of the constant guidance of my father, also a lover of mechanics, and a man of no mean attainments in mathematics and their application to physics" [1]. At Cambridge, Reynolds was a successful mathematics student, passing the mathematical trios in 1867 as seventh wrangler and receiving a fellowship, again like his father, at Queen's College. He thereupon entered he civil engineering firm of John Lawson.

In the following year a newly created professorship of engineering was advertised at Owens College, Manchester, at £500 per annum. Reynolds applied for he position and despite his youth and inexperience, was aware de the post. Subsequently during the thirty-seven years of his tenure as professor, Reynolds investigated and contributed significantly to a wide variety of engineering and physics subjects.

From of 1868 to 1873 Reynolds' attention focused largely on problems in electricity, magnetism, and the electromagnetic properties of a solar and cometary. For the next two decades after 1873, his interests appear to have turned sharply toward mechanics, and especially toward the mechanics of fluids.

In an important paper of 1883, "An Expreimantal investigation of the Circumstances which Determine whether the Motion of Water Parallel Channels shall be Direct or Sinuous and of the Law of Resistance Parallel Channels" [2], Reynolds experimently investigated the character of liquid flow through pipes and channels, and he demonstrated streamline and turbulent flow in pipes. He showed that there is a critical velocity, depending upon the kinematic the diameter of the pipe, and a physical constant (the Reynolds number) for the fluid at which a between the two types of flow will occur. The "Reynolds stresses", resulting from his analysis, continue to play an important role in turbulence theory.

In 1886 Reynolds published "On the Theory of Lubrication" [3] which became a classic paper on film Lubrication, and which rested in bearings that were capable of carrying high loads at speeds hitherto considered impossible.

Reynolds' analogy, which assumes that the rate of transfer between a fluid and its boundary is proportional to the internal diffusion of the fluid at and near the surface, was enunciated in a paper of 1874 [4].

Reynolds' most extensive expremental work concerned the mechanical equivalent of heat; specifically, he found the mean specific heat of water (in terms of work) between the freezing and boiling points. The results rank among the classic determination of physical constants.

Reynolds also worked on the action of waves and currents in determining the character of estuaries, using models in the investigation; the development of turbines and pumps; studies on group-velocity, in which, according to Lamb, Reynolds was the first to show that group-velocity also provides the rate of transmission of energy; the theory of thermal transpiration; investigations of the radiometer; studies on the refraction of sound; and capitation.

In 1885 Reynolds gave the name "dilatancy" to a peculiar property of a closely packed granular mass: it can increase the volume of its interstices when its shape is altered. Reynolds believed he saw in this phenonmenon a possible aether-model explaining cohesion, light, and gravity, these speculations formed the basis for his 1902 Rede lecture, "On an Inversions of Ideas as to the Structure of the Universe", and after ward appeared in mathematical from as *The Sub-Mechanics of the Universe* (Cambridge, 1903; also as Volume III of Reynolds' *Papers on Mechanical and physical Subjects*.). In these papers Reynolds argued that, contrary to the vision of the kineticists, the universe is almost completely filled with absolutely rigid granules- as he insisted at the Rede lecture in 1902, "I have in my hand the first experimental model universe, a soft in did rubber bag… filled with small shot" [5]. He had, he said, "the fullest confidence that ideas, such as I have evdavoured to sketch, will ultimately prevail" [6]. George H.Bryan, reviewing *The Sub-Mechanics in Nature*, was impressed and wrote, "It may be confidently anticipated that Prof. Osborne Reynolds' granular medium will play an important part in the physics of the future" [7].

In a sense, Reynolds' mechanical model-although moribund at its birth-was a suitable end to a distinguished career dedicated to the proposition that to "mechanical progress there is apparently no end: for as in the past so in the future, each step in any direction will remove limits and bring in past barriers which have till then blocked the way in other directions; and so what for the time being may appear to be a bend in the road" [8].

Reynolds was an active and dedicated member of the Manchester Literary and Philosophical Society, which he served as secretary for many years and as president for the term 1888–1889. Upon the death of Joule, he wrote an excellent biography, which was published in the Society's *Memories* for 1892. In 1877, Reynolds was elected a fellow of the Royal Society. In 1888 he also received a Royal Medal and in 1884 honorary LL.D from the University of Glasgow.

Because of ill health, Reynolds retired from active work in 1905. He spent his last years with greatlyimpaired mental and physical powers in Somerset. He left three sons and a daughter by his second marriage.

NOTES

1. Quoted in H. Lamb, "Osborn Reynolds," in *Proceedings of the Royal Society*, **88A** (1912–1913), xv.

2.*Philosophical Transactions of the Royal Society*, **174** (1883), 935–982.

3.*Ibid*., **177** (1886), 157–234.

4. "On the Extent and Action of the Heating of Steam Boilers," in *Proceedings of the Manchester Literary and Philosophical Society*, **14** (1874–1875), 8.

5.*On an Inversion of Ideas as to the Structure of the Universe*(Cambridge, 1903),28.

6. Ibid., p. 44.

7.*Nature*, **68** (1903), 602.

8. O. Reynolds, *Report of the 57th Meeting of the British Assocation for the Advancement of Science* (1887), 861.

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I. Original Works. Reynolds' most important papers are collected in Osborne Reynolds, *Papers on Mechanical and Physical Subjects*, 3 vols. (Combridge, 1990–1903). Useful also in *On an Inversion of Ideas as to the Structure of the Universe* (Cambridge, 1903). His address to Section G of the British Association can be found in the Association's *Reports* (1887), 855–861. Good samples of Reynold' popular style can be found in "The two Manners of Motion of Water" and "Experiments Showing Dilatancy," in *Proceedings of the Royal Institution of Great Britain*, **11** (1884–1886), 44–52, 354–363. J. J. Thomson's views on Reynolds as a teacher are in his *Recollections and Reflections* (London, 1936). Reynolds' "Memori of James Prescott Joule," *Memoris and Proceedings of the Manchester Litercary and Philisophical Society*, 4th ser., **6** (1892), is still the major book-length study of Joule.

II. Secondary Literature. The Osborn Reynolds Centenary Symposium at the University of Manchester (September, 1968) has produced a valuable vol. about Reynolds and his contribution to engineering: D. M. McDowell and J. D. Jackson, eds., *Osbotne Reynolds and Engineering Science Today* (Manchester, 1970), with a lively essay, Jack Allen, "The Life and Work of Osborne Reynolds" (pp. 1–182). To be consulted also are Horace Lamb, "Osborne Reynolds 1842–1912," in *Proceeding of the Royal Society*, **88A** (1912–1913), xv-xxi; A. H. Gibson, *Osborn Reynolds and His Work in Hydraulics and Hydrodynamics* (London, 1946); and "Prof. Osborne Reynolds, F.R.S." in *Nature*, **88** (1912), 590–591.

See also R. W. Bailey, "The Contribution of Manchester Researches to Mechnical Science," in *Proceesings of the Institution of Mechanical Engineers*, **2** (1929), 613–683, with a discussion of Reynolds' mechanical work. On hydraulics, see H. Rouse and S. Ince, *History of Hydraulics* New York, 1963), 206–212. On Reynolds at Owens College, see J. Thompson, *The Owens College: Its Foundation and Growth* (Manchester, 1886). For a brief description of Reynolds' construction of the universe and his own interesting reaction to it, see G. H. Bryan, "A New Mechanical Theory of the Aether," in *Nature*, **68** (1903),600. A fuller bibliography on Reynolds can be found at the close of Allten's essay. I have had the privilege of constuling an unpublished biographical sketch by Hunter Rouse and a private communication by Prof. Stanley Corrsin of the Johns hopkins university.

Robert H. Kargon