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Edited by Peter A. Davidson , Yukio Kaneda , Keith Moffatt , Katepalli R. Sreenivasan

Excerpt

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# 1

## Osborne Reynolds: a turbulent life

Brian Launder and Derek Jackson

### 1.1 Introduction

#### 1.1.1 Scope

Articles on Osborne Reynolds' academic life and published works have appeared in a number of publications beginning with a remarkably perceptive anonymous obituary notice published in *Nature* within eight days of his death (on 21 February 1912) and a more extensive account written by Horace Lamb, FRS, and published by the Royal Society (Lamb, 1913) about a year later. More recent reviews have been provided by Gibson (1946), a student of Reynolds and later an academic colleague, by Allen (1970), who provided the opening article in a volume marking the passage of 100 years from Reynolds taking up his chair appointment at Manchester in 1868, and by Jackson (1995), in an issue of *Proc. Roy. Soc.* celebrating the centenary of the publication of Reynolds' 1895 paper on what we now call the Reynolds decomposition of the Navier–Stokes equations, about which more will be said later in the present chapter. A significant portion of the present account is therefore devoted to Reynolds' family and background and to hitherto unreported aspects of his character to enable his contributions as a scientist and engineer to be viewed in the context of his life as a whole. While inevitably some of what is presented here on his academic work will be known to those who have read the articles cited above, archive material held by the University of Manchester and The Royal Society and other material brought to light in the writers' personal enquiries provide new perspectives on parts of his career.

#### 1.1.2 Family background

Osborne Reynolds came from a well-established Suffolk family with strong clerical connections (Crisp, 1911), which between 1800 and 1880 owned some

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500 acres of land and much of the property around the small village of Debach located about 5 miles NNW of Woodbridge (White, 1844). Starting in 1779, three consecutive rectors of the parish of Debach-with-Boulge came from the Reynolds family. The Rev. Robert Reynolds was instituted on 6 September 1779 on his own petition. When he retired in September 1817 his son, the Rev. Osborne Shribb Reynolds, became Rector. Then, on *his* death in December 1848, his eldest son, the Rev. Osborne Reynolds, took over for a while. This last named, father of the main subject of this chapter, entered Cambridge University in 1832 as a fee-paying pensioner. After matriculating from Trinity College in 1833, he transferred to Queens' College from whence he graduated in 1837 as 13th Wrangler (Venn, 1954). At that point it seemed that he was destined to follow a clerical career like his father and grandfather before him for he was ordained a deacon in Ely Cathedral the following year and became a priest a year later.

The Rev. Osborne Reynolds married Jane Bryer, née Hickman, the 22-year-old widow of the late Rev. Thomas Bryer, at Hampstead Church on June 25th, 1839 (*The Times*, 29 June 1839). Their first child, Jane, was born in 1840 and, soon afterwards, they moved to Ireland where the Rev. Reynolds had obtained a position as principal of the First Belfast Collegiate College, in Donegall Place (Martins Belfast Directory, 1842–43, p. 82). Their second child, Osborne, was born on 23 August 1842 (Crisp, 1911).

It seems, however, that the Rev. Reynolds still saw a career in the church as his goal for in 1843 he returned to England with his family to take up an appointment as curate at the parish church in Chesham, Buckinghamshire. However, his tenure of this post proved to be short-lived. On February 6th, 1844, his wife died as a result of complications following the birth, three weeks earlier, of their second son Edward (*The Times*, 12 February 1844), leaving the Rev. Reynolds with the responsibility of bringing up his three small children alone. That task, allied with the financial limitations of his post as curate at Chesham, provided the incentive for him to seek an alternative position. In October 1845 he was appointed headmaster of Dedham Grammar School in Essex.

The Rev. Reynolds took up his post at the end of 1845 and held it for almost eight years (Jones, 1907). Besides carrying out his duties as headmaster he provided the personal tuition of his children, who lived with him at Dedham (1851 Census of Great Britain). It seems that he was also working on inventions, for while in post he took out the first two of the six patents that would be registered in his name (Ramsey, 1949).

In fact, the small market town of Dedham is located only some 25 miles south-west of Debach. This relative proximity meant that the Rev. Reynolds was able to keep very much in touch with his father, the Rev. Osborne Shribb

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Reynolds, and with the family's farming interests in Debach (White, 1844). On visits there he occupied a farmhouse on the family estate. Moreover, when his father died in post in 1848, the Rev. Osborne Reynolds was able to take over as rector, which he did on his own petition (White, 1844), while remaining headmaster of Dedham Grammar School (Clergy List, 1850, p. 14). This arrangement lasted until May 1850 when a replacement was appointed rector by the Church of England (Crockfords Clerical Directory, 1850). Family misfortune still seemed to stalk the Rev. Reynolds, for the following year his ten-year-old daughter, Jane, died at Dedham.

In 1854, having inherited much of the land and property in Debach, he resigned as headmaster at Dedham Grammar School (or 'was persuaded to resign', as one contemporary account (Jones, 1907) seems to imply) to take on what amounted to the life of a gentleman farmer, managing the family estate in Debach which then employed some 30 staff (1861 Census of Great Britain). He lived at Debach House with his two sons whom he continued to educate, concentrating, it seems, on mathematics and mechanics. As will be seen later, his elder son Osborne warmly acknowledged his father's role in stimulating his own interest in mechanics. By the time of the next census (1871) his sons had both gone up to Cambridge University leaving Osborne Reynolds Senior free to concentrate on managing his estate and farming interests which, apparently, continued to flourish. Later, however, in the agricultural depression of 1879, it appears that Osborne Reynolds Senior encountered financial difficulties. In 1880, at the age of 66, he relinquished the estate to take up the post of rector of Rockland St Mary in Norfolk (a placement arranged under the auspices of his Cambridge College, Queens' (Crockfords Clerical Directory, 1880, p. 839)). He finally retired in 1889 and moved to Clipston, Northamptonshire, where his younger son, Edward, was then rector (Crockfords Clerical Directory, 1890, p. 1069) and he died there on June 7th the following year (*The Ipswich Journal*, 14 June 1890; *The Manchester Guardian*, 18 June 1890).

In summary, the talented but ill-fated Rev. Reynolds had an exceptionally strong influence on the formation and development of his elder son, Osborne Reynolds, who forms the subject of the remainder of this article. Not only was he directly responsible for Osborne's primary and secondary education but he stimulated in him a fascination for mechanics that was to be the bedrock of his life's work. He went on to play a major role in shaping the path and covering the not inconsiderable cost of the further five years which his son spent receiving practical training in mechanical engineering and a university education in mathematics which were so pivotal to his subsequent career. Moreover, the manner in which the Rev. Reynolds coped with the serious domestic misfortunes he faced must have provided a source of inspiration for his son

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Osborne when strangely parallel developments later threatened to derail his own life.

### 1.1.3 Osborne Reynolds: education and first professional steps

As noted above, Osborne Reynolds Junior was born in August 1842 in Belfast where the Rev. Reynolds was briefly Principal of the Collegiate School. Despite the brevity of the family's stay there, numerous Irish history websites include Osborne Reynolds in their listings of famous Irishmen, lists that also include Sir George Stokes and Lord Kelvin, the former of whom plays a significant role later in this account.

At the age of 19, having acquired from his father not just his schooling but also a fascination for mechanics, Osborne Reynolds entered the engineering workshop of Edward Hayes of Stony Stratford, a well-known trainer (and teacher) of mechanical engineers. There, typically, a dozen 'privileged apprentices' (or, more transparently, since fees of up to £300 per annum were charged, the sons of wealthy families) would be taking their first steps in learning the rudiments of engineering manufacture, management and science (*The Engineer*, 14 September 1877, p. 183). The nature of the training is well brought out by the following:

The pupils... who stood out at the works in their white overalls... were instructed in every aspect of the business, turning, fitting, erecting and other trades, and were trained not by the workmen, but by the Hayes foremen, and to a large extent by Edward Hayes himself. Whilst at the Works they had to conform to all the general rules and hours worked by the labour force. Most evenings were also spent with Edward Hayes being instructed in the technicalities of drawing, planning and estimating. Other subjects taught were mathematics, mechanics and natural philosophy... The pupils received... a thorough grounding in the basis of engineering theory as well as shop-floor experience, to enable them to qualify as professional engineers, who could undertake all types of design work...

(from Neil Loudon, *Boats without Water*, unpublished ms, personal communication).

Reynolds' object in taking this placement, as explained later in a testimonial provided by Mr Hayes, was "to learn in the shortest time possible how work should be done and, as far as time would admit, to be made a working Mechanic before going to Cambridge to work for Honours" (University of Manchester Archive). Indeed, in 1863 Osborne Reynolds was duly admitted as a pensioner to Queens' College at the comparatively late age of 21 to read mathematics – too old to be eligible for the recently established entrance scholarships. Moreover, his father's tuition had failed to include instruction in classical Greek on which, to his annoyance, he thus had to devote many hours

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of private study. On passing the requisite examination early in his second year he ceremonially demonstrated his firmness of spirit by burning all his Greek textbooks despite the pleas of his friend and fellow undergraduate at Queens', Arthur Wright, who was studying classics, to pass them on to him (Wright, 1912).

In his specialist subject of mathematics Osborne Reynolds also viewed his experience at Cambridge with some disappointment. Years later (13 October 1876) at a General Meeting of the Manchester Mechanical & Physical Society he declared:

The mathematical education given at Cambridge, however much it might develop the power of mind of its possessors, [was] hardly calculated to forward the study which was its immediate object. Those who did attempt such a course found that they had spent several years in learning that which they had to lay aside on commencing their new work. Mathematics and the theory of mechanics, it is true, were then as now, the educational base most wanted; but these taught with a view to their application to the simpler problems of astronomy ... were about as much use as the Latin grammar ... for learning French.

Nevertheless, Reynolds graduated with a BA in 1867 as 7th Wrangler (Venn, 1954). However, this level of distinction did not come easily to him, as a quotation from one of his tutors will show. Thereafter, Osborne Reynolds took up employment with the well-known firm of civil engineering consultants, Lawson & Mansergh (Allen, 1970) in London. Within a few months, news reached him that Owens College, Manchester, had advertised the creation of a Chair in Civil and Mechanical Engineering. On January 18th, 1868 he duly wrote a letter of application (University of Manchester Archive) that began:

Gentlemen, I beg leave to offer myself as a candidate for the Professorship of Engineering at Owen's [sic] College. I am in my twenty-sixth year. From my earliest recollection I have had an irresistible liking for mechanics; and the studies to which I have especially devoted my time are mechanics and the physical laws on which mechanics as a science are based. In my boyhood I had the constant guidance of my father, also a lover of mechanics and a man of no mean achievement in mathematics and their application to physics.

The hand-written opening of this letter is reproduced in Figure 1.1.

### **1.1.4 Chair application at Owens College**

The Chair, which was initially advertised at a salary of £250 per annum (University of Manchester Archive), attracted 16 applications including those of Osborne Reynolds and a William Cawthorne Unwin who will also appear later in this account. Much has been made of Reynolds' youth and (thus) his

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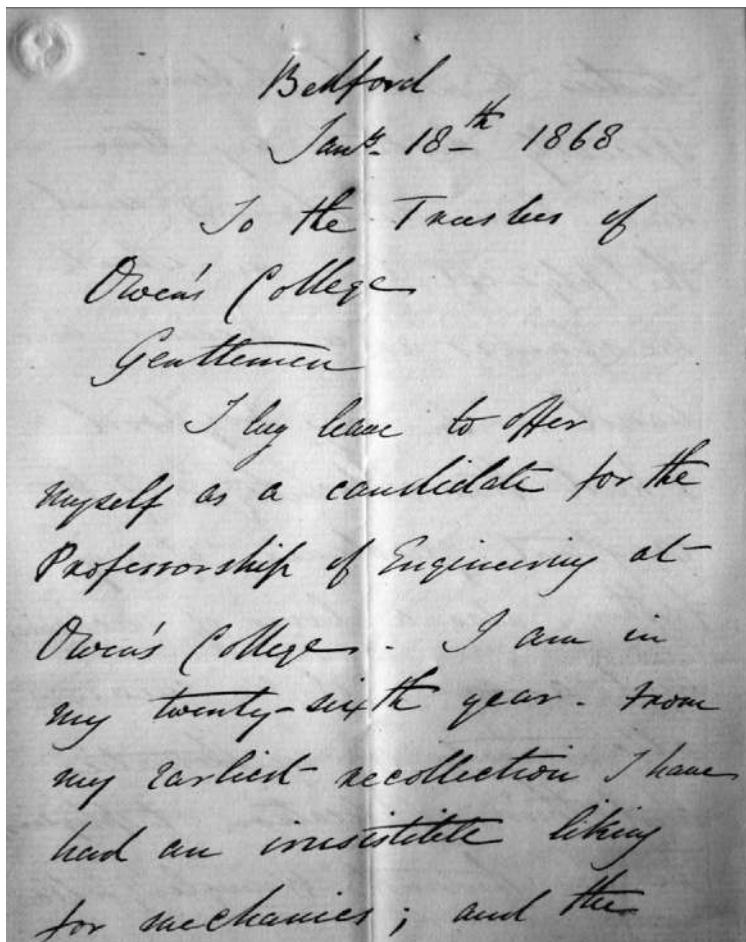


Figure 1.1 The opening page of Osborne Reynolds' letter of application for the Chair in Engineering. Reproduced with permission of the University of Manchester.

audacity in applying for the Chair and, equally, the wisdom of the appointing committee in eventually choosing him. However, Reynolds was by no means the youngest candidate: seven of the 16 were in their twenties, four of whom were younger than Reynolds. In the 1860s, a sound knowledge of mechanics and a vision of where it might lead in engineering applications must have been qualities predominantly possessed by younger candidates, much as knowledge and competency in certain aspects of software engineering are today.

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W.C. Unwin must have felt that he had a good chance, having been assured of very strong support from his former employer and mentor, William Fairbairn, FRS (Allen, 1970), who was chairman of the committee of industrialists in Manchester which had raised the money to fund the Chair. The College set up an appointing committee made up of trustees of Owens College and a selection of professors. Fairbairn was not on that committee but, evidently, he must have been influential behind the scenes in guiding it with a view to ensuring that a suitable appointment was made. The procedure was for candidates to submit supporting testimonials and, in Reynolds' case, at least, the handwritten versions (of which there were 14) were complemented by a printed version of the same and of his letter of application itself (University of Manchester Archive). The testimonials included one from Mr Hayes from which the quotation above was taken, another from Archibald Sandeman, then Professor of Mathematics at Owens College but who had formerly been Reynolds' tutor at Queens' College, plus four others from Cambridge staff including one from James Clerk Maxwell, FRS, confirming Reynolds' standing in the graduation list and ending with the important observation that

I had to examine Mr. Reynolds' papers for the Mathematical Tripos, including his solutions of many questions in mechanics and general physics; and found that he had knowledge of sound principles which will enable him in the study and teaching of engineering to exemplify the practical use of sound theoretical principles, and to show that all his practical rules are founded on general laws established by experiment.

Another referee, the Rev. W.M. Campion, BD, Fellow and Tutor of Queens' College, Cambridge, wrote:

Mr. Reynolds is an accomplished Mathematician. But he is not a mere theorist. He possesses a considerable acquaintance with practical mechanics and engineering. For more than a year before he came to the University he studied the practice of the profession under Mr. Hayes of Stoney Stratford; and since taking his degree he has been occupied in like manner with Mr. Lawson of London. It would be difficult to find a Mathematician who combines such practical experience with theoretical knowledge.

Fulsome communications were also received from J.C. Challis, FRS, Professor of Astronomy, and the mathematics tutor, John Dunn, who commented that while on entry Reynolds had lacked knowledge in mathematics, “by innate talent and undeviating perseverance Mr Reynolds made the most rapid progress”.

Perhaps most surprisingly to a 21st-century reader, his father, the Reverend Osborne Reynolds, also provided a testimonial (at the suggestion of another referee), a task which, in his words, had surprised and embarrassed him. He

nevertheless praised his son's qualities and concluded: "The only point I can conceive against him is his youth – he is only in his 26th year. But this is compensated for by his early devotion to Science and the practice of his profession".

Despite the considerable number of applications, the minutes of a meeting of the Owens Committee of Trustees on 30 January 1868 reported reservations on the part of the appointing committee about the response to the advertisement. Accordingly, Mr Charles F. Beyer, a German who had come to Manchester as an impecunious young man to make his fortune (and had certainly done so!), offered to provide sufficient further funds to enable the post to be re-advertised with "an additional £250 p.a. for the first five years in the hope that the increased remuneration would enable the Trustees to obtain applications from gentlemen of higher scientific attainments and greater professional experience than could be expected under the moderate inducements held out in the earlier advertisement" (University of Manchester Archive). It is more than likely that this decision was influenced by the following sarcastic article which had appeared in the professional journal, *Engineering*, earlier that month (10 January 1868):

#### Technical Education

For all those who are interested in that subject of paramount national importance, upon which the future greatness of this country and its position in the civilised world are now recognised to depend – for all those who are speaking, and writing, and working for the spread of technical education in this country – we have gratifying news. The trustees of Owens College, in Manchester, are advertising for an able-bodied man-servant to act as performing professor of engineering for the rising generation in the metropolis of Manchester, at the liberal rate of wages of thirteen shillings and eight pence per day.

What a stir this grand opening will create in the scientific world! The greatest men of Great George street will close their offices and compete with each other; M. Flachat, Professor Conche, Baron Burg, and Professor Ruhlmann will leave their respective countries and professors' chairs; men like Rankine, Scott Russell, and Clausius will gather in long processions in the streets of Manchester, and vie with each other to answer the call in the newspapers. Thirteen and eight pence and a proportion of the fees paid by students (and perhaps the free loan of a sewing machine for the professor's wife to earn a little extra) are worth applying for in a country where the income of the head master at Eton is estimated at £6000, and that of an assistant master at the same school ranges from £1500 to £3500 a year.

In any event, a further 11 applications were received in response to the re-advertisement with its upgraded salary, and there had also clearly been discreet contact with Professor William Maquorn Rankine, FRS, at the University of Glasgow who, after initially showing some interest in the post, chose not to

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pursue the matter. Thus the Trustees decided to interview “Mr George Fuller, C.E., Associate of the Institution of Civil Engineers and Mr Osborne Reynolds, B.A., Fellow of Queens’ College, Cambridge whom they believe to be the most eligible” (University of Manchester Archive). Both interviewees were drawn from the original list of applicants. Thus, with Rankine having eventually declined to become a candidate, the increased offer had served nothing other than to double the salary of the successful applicant. As the world of fluid mechanics gives thanks, the chosen candidate was Osborne Reynolds, a decision which has been described by Smith (1997) as “an inspired choice and one of the most successful gambles ever made by an appointing committee”. A photograph of part of the formal terms of appointment is reproduced in Figure 1.2. As for W.C. Unwin, as soon as the Trustees’ decision had been reached, his former employer wrote to him (Walker, 1938):

My dear Unwin,

I am very sorry I cannot forward to you the agreeable intelligence that you are elected to the position of professor. I so earnestly wished for you to occupy that position. It would have exactly suited your tastes, and I had every reason to believe you would have been an active and excellent professor.... In wishing you better luck in your next undertaking, I am,

Yours,

Wm. Fairbairn.

The commissioned biography of Unwin (Walker, 1938), as works of that kind inevitably are, was staunchly supportive of its subject. Ignoring the fact that Unwin was not one of those invited for interview, it nevertheless chose to present the chair appointment as a contest between Unwin and Reynolds that involved at least misjudgement by the interviewing committee and perhaps political intrigue to boot:

Bearing in mind the researches on materials and on bridge design which he at that time had recently completed... it is certainly remarkable that no better reason could be adduced by the College authorities for passing over Unwin in favour of one whose experience of civil engineering was less, and whose fame rests upon his work as a physicist rather than as an engineer. Owen’s [sic] College at that date was, to a very great extent, a municipal undertaking and one cannot help thinking that, in the lively atmosphere that surrounded its early development, considerations other than academic may have played some part in the deliberations of the Senate.

It is noted for the record that none of the documents seen in the University of Manchester’s archives lends any support to Walker’s insinuation that “considerations other than academic may have played some part” in the decision. The

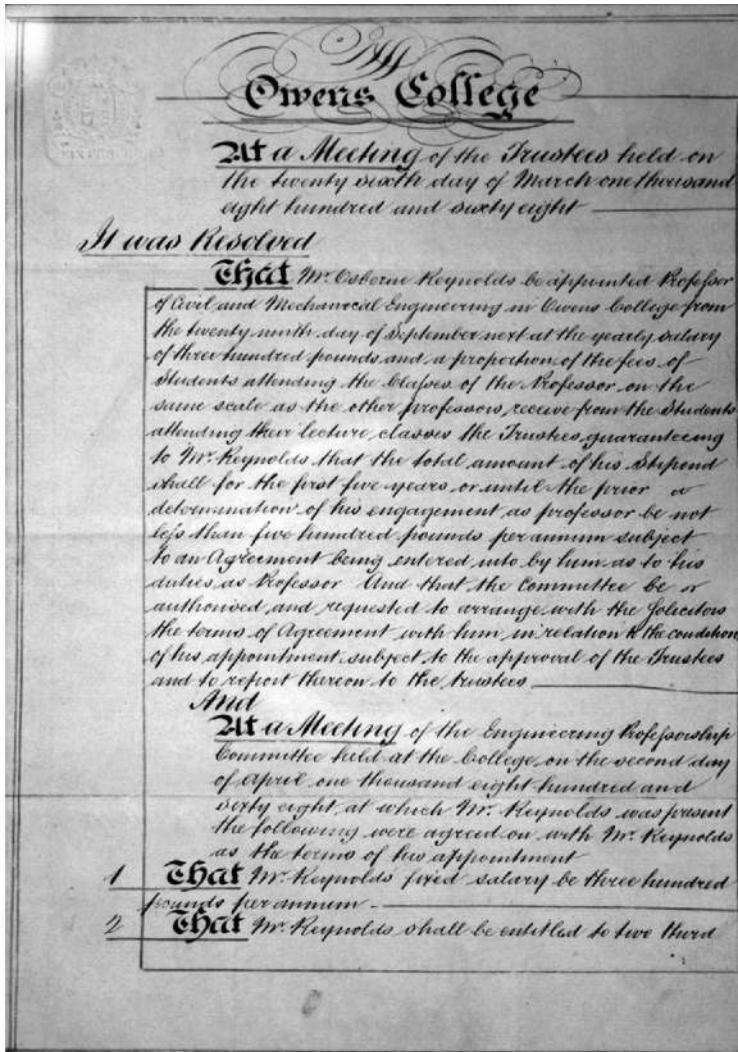


Figure 1.2 Opening portion of the terms of Reynolds' appointment as Professor of Civil & Mechanical Engineering, © The University of Manchester. Reproduced by courtesy of the University Librarian and Director, The John Rylands University Library, The University of Manchester.

creation of the Chair was the outcome of leading industrialists from Manchester recognizing the need to underpin the region's industrial strengths with a skilled and knowledgeable professional workforce. Moreover, few if any would agree with Walker's suggestion that Reynolds' subsequent "fame"