A FAMILY OF ASTRONOMERS - THE BREENS OF ARMAGH

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SUMMARY. An unusual family in the annals of astronomy was that of Hugh Breen of Armagh (1791–1848) who with his sons Hugh (b.1824), James (1826–1866) and John William (1832–1871) provided four working astronomers to the staff of the Royal Observatory Greenwich and the Cambridge University Observatory in the 19th century. Though none rose to high office, the Breens were intelligent and competent mathematicians who gave useful service to their institutions as calculators and observers. Two of the sons, Hugh and James, extended their talents to popular writing.

1. The BREEN FAMILY

The first to draw attention to the remarkable Breen family was T. George F. Paterson in the course of a lecture delivered in 1950 to the Armagh Branch of the Irish Astronomical Society of which he was a member, subsequently published in the *Irish Astronomical Journal*[1]. Paterson (1888–1971), Curator of the Armagh County Museum, was a noted scholar with an encyclopedic knowledge of local history, archaeology and folklore[2]. In that paper he summarises the life of the elder Hugh Breen as a teacher in Armagh and later as an astronomer at the Royal Observatory; and outlines the careers of his three sons, all keen astronomers, who followed in his footsteps. He concludes: "The Breen record of father and three sons, all astronomers, is probably without parallel in astronomical chronicles".

2. HUGH BREEN

2.1. Armagh 1791–1831

Little is known about the family background of Hugh Breen or about his education or of how he acquired his mathematical skills. He was a native of Armagh but was living in Dublin in 1826 when, at the age of 35, he was appointed teacher of science and head of the Scientific School in the newly instituted Armagh Mechanics' Institute. He cannot, however, have been resident in Dublin for more than a couple of years, as his first two children were born in Armagh in 1822 and 1824.

The interesting history of the short-lived Mechanics' Institute in Armagh has been thoroughly researched by Seamas S. Duffy[3]. The idea of teaching science to mechanics and artisans originated in Glasgow with the Andersonian Institute, so-named after its founder, in the 1790s. The Mechanics' Institute movement soon spread to other cities in Great Britain, notably Edinburgh, London, Liverpool and Belfast. The inspiration for a similar Institute for Armagh came from a local Member of Parliament at Westminster, Henry Caulfield, who chaired a public meeting called to discuss the matter in October 1825. The object of the Institute was to teach the arts (meaning, in those days, crafts) and sciences; there was to be a library, a museum with models and demonstrations, and a laboratory for mechanics and chemistry. In spite of opposition from certain influential citizens the Institute was brought into being in January 1826, when it was decided to advertise for the important post of teacher in charge of what was called the Scientific School. This was the post that Hugh Breen applied for and was appointed to.

Breen's salary was £40 per annum and a free house, plus a sum to defray his travelling expenses from Dublin. "There is little doubt", writes Duffy, "that in Breen the Armagh Institute obtained a man of considerable talent" who worked very hard for the success of the Scientific School. He was, according to Paterson, "a mathematician of no mean order"[4], the author of a privately printed treatise "On the summation of series" which he dedicated to one of the Patrons of the Institute, the scholarly Sir Capel Molyneux of the local leading family which included the 18th century politician and astronomer Samuel Molyneux[5].

The curriculum laid down for the Scientific School comprised instruction in arithmetic, algebra, geometry, trigonometry, mensuration and surveying[6]. Teaching began with a handful of young boys of about twelve years of age; but public lectures for adults were also introduced, which Breen was asked to give. For this he required demonstration apparatus, which he was sent to Dublin to purchase. The list of his acquisitions for his course in mechanics is preserved: it included a stand with ivory balls to demonstrate collisions, models of levers, pulleys of various sizes, friction wheels, syphons and airpumps[7].

Unfortunately, after some years, a variety of problems, including financial ones, developed. The Institute began to decline in spite of efforts to attract the public to its courses with offers such as family fees and evening lectures. Breen was still on the staff in 1830, but the Institute, sadly, ceased to function in 1831.

Hugh Breen and his wife Mary (née Magee) had three children, all born in Armagh - a daughter Maryann, baptised on 1 August 1822, and two sons, Hugh, baptised on 11 April 1824 and James, born on 5 July and baptised on 10 July 1826[8]. The family was Catholic. Breen's wife must have died young. His third son, John William, born in 1832 was the child of his second marriage[9].

Breen did not sever his links with Armagh when he left. At least one of his sons, James, was educated in his native city.

2.2. Greenwich 1835?–1848

Some time after the collapse of the Mechanics Institute Breen found employment suitable to his mathematical abilities at the Royal Observatory Greenwich. We have not established exactly when he joined the Greenwich staff but his activities were associated with the incumbency of G. B. (later Sir George) Airy who took office as Astronomer Royal in 1835.

Breen worked on reductions of the elements of planetary orbits using the vast store of Greenwich observations dating back to 1750, an immensely important project undertaken and seen through by Airy[10]. Several young men were recruited as "computers" or "calculators", working long hours to speed through this task. In 1840 a similar project for observations of the moon was tackled which, according to Sir William McCrea, was regarded by Airy as "the greatest astronomical work ever undertaken"[11]. Hugh Breen was responsible for overseeing these lunar reductions, and was the author of an official Report published in 1848 - the very year of his death - dealing with observations made between 1750 and 1830[12].

Hugh Breen's taste for mathematics, as well as his skill, may be further inferred from a paper by Hugh Breen Junior (Section 3 below), published a few months after his father's death. It concerned an analysis of a method of deriving the elements of the orbit of Venus, a piece of work begun by the father who "was curious to examine the mathematical process used... for correcting the elements."

2.3. The Breen Era

Hugh Breen, during his years in office, succeeded in getting posts - lowly to begin with - at Greenwich for all three of his sons. Each in turn began as a calculator (or computer) at the age of about 15 - Hugh Junior in 1839, James in 1840 and John William in 1846. As already mentioned, Sir George Airy made much use of such young men for routine work. The most junior (supernumerary or temporary) computers could progress to an established computership. It was possible for exceptionally able computers to be promoted to the rank of "assistant" when a vacancy occurred.

There does not appear to have been a time when all four Breens were on the Greenwich staff together (the youngest, John William, arrived at about the time that James left); however, for many years there were three Breens - father and two of the sons - serving simultaneously. The Breen era, from the father's appointment to the departure of the youngest son, spanned at least 20 years[13].

Hugh Breen died in his 57th year on 1 April 1848[14], and is buried in Nunhead cemetery in South east London. The family grave is marked by a tomb.

3. HUGH BREEN JUNIOR

3.1. Greenwich 1839–1859

The eldest of Hugh Breen's sons, also named Hugh, began work in Greenwich at the age of 15 in 1839[15] as a calculator, working on the reductions of the old planetary and lunar observations. A year later he applied for a newly created post in the Observatory's Magnetic Department[16], but was considered too young and not strong enough for the duties[17]. In 1842 he began occasional night duty with the meridian instruments; in the course of time he was to gain experience with all the observatory's astronomical instruments.

In 1845 Hugh Breen offered himself[18], supported by his father[19], as a candidate for a forthcoming new post of Assistant in the Astronomy Department. This responsible post, to which he was in fact appointed on 1 January 1847, put him in charge of the new alt-azimuth telescope acquired by Airy to obtain improved observations of the positions of the moon and an increase in the precision of tables of the moon's motion[20]. The salary was £100 a year plus £30 allowances[21], and his position on the staff hierarchy was that of 5th Assistant (out of six; the First Assistant was next in rank to the Astronomer Royal and had special status).

Hugh Senior died the following year. Hugh Junior's computational work made him for a time a partner with him in the programme of computing the elements of planetary orbits. As already mentioned, their work in this field, concerning the orbit of Venus, was published soon after the father's death in 1848 by Hugh Junior[22], with the assistance of his brother James, then at the Cambridge Observatory. That paper communicated to the Royal Astronomical Society by the Astronomer Royal, recorded that upwards of one thousand observations of the planet Venus were available, contained in the Greenwich observations between 1750 and 1830. The elements of Venus' orbit, deduced by Bernhart von Lindenau from much earlier observations, predicted positions of the planet which were different from those observed. Corrections to these elements were calculated from a comparison of the predicted and observed positions. The paper, the combined work of three members of one family, is perhaps worthy of remark (Figure 1).

In 1851 Breen was put in immediate charge of the Observatory's team of junior computers and was made general supervisor of all computational work and of seeing the results through the press. In 1852, the Council of the Royal Astronomical Society drew attention to the work on the elements of the planet Mars by Mr H. Breen "who is well known as an able and zealous computer"[23]. It noted that the whole of the work on Mars was his, while that on Venus had been begun by his father.

By 1853 Hugh Breen had risen to the rank of third Assistant, which he retained until his retirement.

3.2. The Natural History of Inanimate Creation

Outside his professional duties, Hugh Breen found time to contribute to a substantial compendium of the sciences, *The Natural History of Inanimate Creation*, published in 1856[24]. The full title was *"The Natural History of Inanimate Creation, being A Guide to the Scenery of the Heavens, the Phenomena of the Atmosphere, the Structure and Geological Features of the Earth and its Botanical Productions"*. Five branches of science were covered - geography, geology, botany, astronomy and meteorology - each by a specialist author. "Hugh Breen Esq., Royal Observatory, Greenwich" was the only unadorned name on the title page: the other four authors were academics sporting university degrees and memberships of scientific societies. The principal author David Thomas Ansted FRS was a distinguished geologist, formerly Professor at King's College London[25]. Some of the contributions, including Breen's, appeared in another anthology, on astronomy, navigation and meteorology, brought out by the same publisher[26].

The Natural History of Inanimate Creation was packed with information, and written at textbook rather than at the ordinary popular level. Breen's "guide to the scenery of the

VI. *Corrections of Lindenau's Elements of the Orbit of Venus, deduced from the Greenwich Planetary Observations, from 1750 to 1830.* By Mr. Hugh Breen, of the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.*

Read November 10, 1848.

When we look to the number of observations of *Venus*, contained in the Greenwich Planetary Reductions from 1750 to 1830 (upwards of 1000), which have been uniformly compared with Lindenau's tables, it seems evident that corrections of his elements deduced from so extensive a series of observations, would be valuable. Impressed with the utility of such a work, my father, the late Mr. Hugh Breen, undertook the task, with the assistance of myself and brother, Mr. James Breen, assistant to the Cambridge Observatory.

Previously to the commencement of the work, he was curious to examine the mathematical process used by Lindenau for correcting the elements, which he has given in the introduction to his tables.

The method by which Lindenau has corrected the elements of *Venus* is as follows:—

Having found the geocentric longitude (l) and latitude (b) from observation, and also the earth's heliocentric longitude (L) and radius vector (R), from the solar tables, he computes, with the projection of the planet's radius vector (r), the heliocentric place by means of the formulæ,—

$$\sin (l-\lambda) = \frac{R}{r} \sin (l-L) \qquad (1)$$

$$\mathrm{Tan}\ \beta = \frac{\Delta}{r} \tan b \qquad (2)$$

* *Reductions of the Observations of Planets, made at the Royal Observatory, Greenwich, from 1750 to 1830, computed by order of the Lords Commissioners of the Treasury, under the Superintendence of George Biddell Airy, Esq., M.A., Astronomer Royal. London: J. Murray, Albemarle Street.* 1845.

Fig. 1. The work of three Breens; Hugh Breen's paper of 1848.

heavens" occupies some 250 of the book's 800 pages. It begins with a historical summary and goes on to give "a comprehensive view of the theories of astronomers, with practical instructions in the modes of observing and recording their results in the Royal Observatory and other similar establishments". Breen's own field of lunar observations and reductions is given particular attention; so, too, is the subject of comets. He describes how to calculate orbits and includes an enormously long table listing every recorded comet from Diodorus of Sicily in 371 BC to 1851.

Breen's section is lavishly illustrated by engravings supplied by the publishers of a book by the French astronomer Charles-Eugene Delaunay. Delaunay (1814–1872), whose new lunar theory was then in course of publication, would have been well-known to Breen at least by repute.

Breen's work in this volume is now long forgotten. It is worth drawing attention to it, however, as a first-hand view of mid-nineteenth century astronomy and, indirectly, of the practical operation of the Royal Observatory, by an active participant.

3.3. An Unhappy Interlude

In 1856 Breen applied to the Astronomer Royal for a rise in salary, pointing out that he had served the Royal Observatory for almost 18 years and had "spent his leisure time in useful ways"[27] - referring no doubt to his recent literary endeavour. He also complained of the difficulty of supporting his family. Two years later, in November 1858, he unexpectedly handed in his resignation, citing family reasons[28]. The Astronomer Royal tried to dissuade him, but to no avail. The resignation took effect from 31 January 1859. According to Paterson, Breen - who was only in his early thirties - resigned because of poor health, but the illness is likely to have been mental rather than physical[29]. He had earlier visited Ireland (his name is in the Visitors' Book in Armagh Observatory on 18 February 1858) and had formed a plan to return there and start a school. In a printed advertisement[30], describing himself as "the son of a late successful teacher of mathematics in Armagh", he announced his intention to establish "a school for young Catholic Gentlemen" in Enniskillen, giving details of subjects, fees and holiday arrangements. There is no record of such a venture in the history of Co. Fermanagh[31], but this is not surprising, as the school was a failure from the start. The efforts of a family friend to forestall Hugh's resignation, came too late[32].

Breen may not have quite given up the idea of a school, however. Paterson records that a plan to open an "academy" in his native Armagh in 1860 was prevented by a nervous breakdown. Breen returned to his family in London and was eventually granted £50 per annum pension for his services to astronomy[33]

3.4. Bouvard's Elements

After his unfortunate venture, Breen seems to have recovered his old interests, though not his old job. He took up astronomical computational work again, with Airy's permission, on a sort of free-lance basis, and may have received some payment for this[34].

One of Breen's proposed projects was a derivation of the moon's horizontal parallax. The moon's parallax (from which is found the distance of the moon) is determined by comparing the moon's apparent position in the sky as seen from widely separated stations on the earth's surface. The results were published officially in 1863 by the Board of the Admiralty and in the Memoirs of the Royal Astronomical Society[35].

Breen persevered, and in 1869 published a substantial piece of work "On the Corrections of Bouvard's Elements of Jupiter and Saturn" in the Royal Society Proceedings[36]. Bouvard was the calculator of tables for the motions of the outer planets, Jupiter, Saturn and Uranus, published in 1821. It was from these tables that the discrepancies between the observed and calculated places of Uranus led to the discovery of the planet Neptune. Breen's paper performed the same task for Bouvard's elements as his earlier one had done for Lindenau's in the case of Venus and Mars. The paper, in which he described himself as "late of the Royal Observatory", was communicated to the Royal Society by the Society's Secretary, the mathematician G. G. Stokes. It was also printed as an appendix to the Greenwich Observations.

Hugh Breen fades out of the astronomical scene after this. The date of his death has not yet been found; he is the only one of the family who does not lie in Nunhead Cemetery.

4. JAMES BREEN

4.1. Greenwich 1840–1846

The second of the Breen sons, James, was educated at the Cathedral Grammar School in Armagh[37] (founded early in the century for the education of choirboys in the Church of Ireland Cathedral) which had about 40 pupils under the tutelage of Rev. James Groves, a graduate of Trinity College Dublin[38]. He started at Greenwich in 1840 at the age of 14, only one year after his brother Hugh, probably as a "supernumerary" or temporary computer, graduating to a proper computer's post after two years[39]. He was employed, with others, in computations connected with the old Greenwich planetary observations. Only in 1846 did he progress to occasional observing with the meridian instruments.

Clearly the Astronomer Royal had his eye on him, for when Professor James Challis at Cambridge Observatory asked if he could recommend an assistant, Airy (in June 1846) suggested James Breen, "a rough genius, but who can get through any quantity of work, and has had much to do not only in reductions of my papers, in drawing plans of the observatory, and the like"[40]. Robert Main, First Assistant at Greenwich, recommended him as "unremitting in industry and always zealous in performing all his duties.....and can read German with facility"[41]. Breen was offered and accepted the post of Junior Observer at Cambridge, to be taken on trial for one month[42] He was in fact appointed Senior Observer from the beginning[43]. The Director (Challis), and the Senior and Junior Observers made up the entire staff.

4.2. Cambridge 1846–1858

James Breen's appointment took place, by coincidence, at a dramatic moment in the history of the Cambridge Observatory. The race was on to discover the unknown planet beyond Uranus which had been independently predicted from theory by John Couch Adams at Cambridge and Urbain J. J. Le Verrier at Paris. Correspondence between Challis and Airy on this vital subject was taking place simultaneously with their exchange of letters about Breen's recruitment[44]. As is well known, priority for the discovery of the new planet, Neptune, on 23 September

1846 went to J. G. Galle, an astronomer in Berlin, who, unlike the Cambridge astronomer, possessed reliable maps of the relevant star fields. It transpired that Challis had actually seen the planet on 4 and 12 August; Breen's letter of acceptance is dated 8 August.

The principal instrument at Cambridge was the Northumberland telescope, named after its donor the Duke of Northumberland, which had a lens of 12 inches diameter and a focal length of 20 feet. Challis used this excellent telescope to observe double stars, planets and comets[45]. As James began his new tasks, his brother Hugh at Greenwich took an interest in the work from a distance, as is evidenced by the fact that he was "lent" observational data by Challis in September 1846 from which to compute cometary ephemerides[46]. This link continued; in 1858 we find Hugh receiving from Challis a copy of the Cambridge Observations[47].

The Breen brothers, both until then living with their father at 17 Park St., Greenwich, and working side by side at the Royal Observatory, had now, at the ages of only 20 and 22 reached responsible permanent posts, James as Senior Observer at Cambridge and Hugh as Assistant at Greenwich. They continued, one imagines, to be very close, and their subsequent careers had much in common.

James remained (in the words of his obituarist[48]) "zealously occupied" at Cambridge for 12 years. Apart from his duties as assistant to Professor Challis, he published some independent observations of double stars and comets[49]. In 1858 Challis and Breen made a series of observations of Donati's Comet, one of the great comets of the century with the Northumberland telescope recording the comet's changing physical appearance from August to October[50].

The observation of Donati's comet was James Breen's last work from Cambridge. He left at the end of that year. His decision appears to have been unexpected; his letter of resignation to Challis implies some misunderstanding and perhaps disagreement; "to prevent any mistake on the subject", he wrote, "I beg leave to state that it is my intention to resign at the end of the present year, which I hope will be convenient to both parties"[51].

4.3. Planetary Worlds 1854

While still at Cambridge, James Breen published a small but excellent popular book, *The Planetary Worlds, the topography and telescopic appearances of the Sun, Planets, Moon and Comets*[52] (Figure 2). He informs the reader in the introduction that he was induced to write it following the attention being directed during that year, 1854, to the question of the plurality of worlds. He was referring to the famous debate between the Scottish physicist and evangelical theologian Sir David Brewster and William Whewell, Master of Trinity College Cambridge, about the origin of the solar system and the possibility of life elsewhere in the universe. Brewster's *More Worlds than One, The creed of the philosopher and the hope of the Christian*[53], published in 1854, was a reply to Whewell's pamphlet *Of the Plurality of Worlds*[54], published the previous year. Essentially, Whewell argued from the long geological timescale and the recent appearance of man on earth against the possibility of other inhabited worlds. Brewster, in his direct point-by-point refutation, contended vigorously that not only the bodies of our own solar system, but worlds surrounding other stars, were all populated according to divine plan.

James Breen's purpose was to provide hard facts about the astronomical universe. The more modern discoveries from foreign institutes and observatories, had, he claimed, received little notice in this country. His small book, of fewer than 300 octavo pages, lays out every known physical datum about the universe but avoids all philosophical speculation. His chapter on comets, his favourite subject, gives details of all the major comets of the previous few centuries. The book is illustrated with numerous drawings, many of the moon and of recent comets, probably his own productions.

James' book, which is entirely descriptive and addressed to the general reader, differs in style from his brother Hugh's mathematically based work of two years later. It is interesting, however, that both brothers should have turned to writing, and even more remarkable that they both resigned their respective posts practically simultaneously.

4.4. Abroad 1859–1861

After Cambridge, James Breen went abroad to broaden his education and perhaps to see something of the world. He went first to Paris, where he attended lectures at the University and studied French literature (he already had a knowledge of German). In 1860 he travelled to Spain to observe the total eclipse of the sun of 18 July in the company of two British amateur astronomers, James Buckingham and William Wray. Buckingham was the constructor of a large equatorial refractor of 21 inches aperture, the lens of which was made by Wray, which he exhibited at the 1862 Exhibition in London and afterwards installed it in his observatory on Walworth Common, London[55].

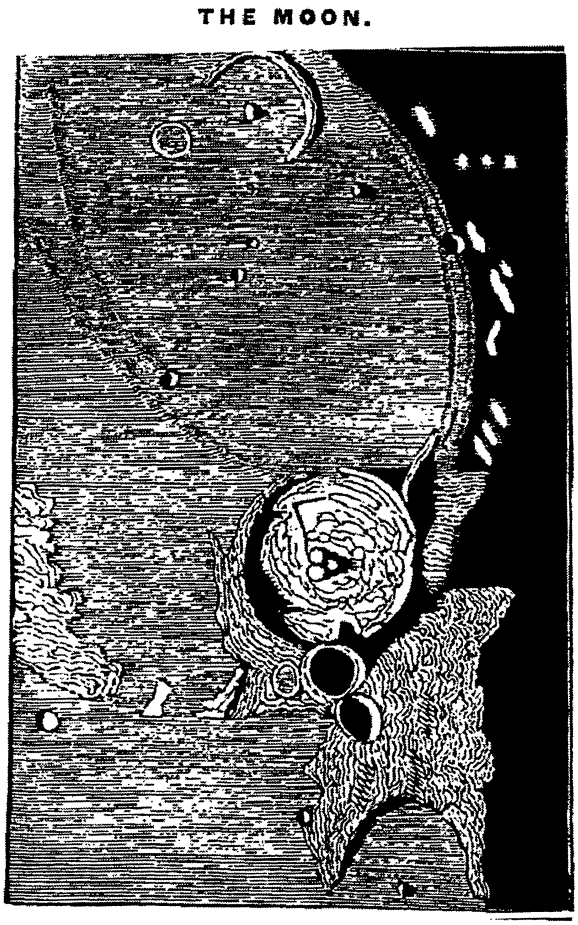
The 1860 eclipse which attracted a large number of observers was notable as the first at which the eclipsed sun was successfully photographed. Observations made during this eclipse also confirmed that the red prominences are a genuine attachment of the sun, and not a meteorological or lunar effect.

Breen and his companions were stationed near Aquilar in northern Spain, but without elaborate equipment. Wray and Buckingham made naked eye observations of the appearance of the corona and of meteorological effects. Breen had a telescope with which he scanned the edges of the sun for prominences during totality. He did not manage to see any, but was able to make a drawing of the corona which was of typical round sunspot-maximum shape and was perceptible to a distance of half the diameter of the moon. His graphic description, taken from his manuscript and illustrated by his drawing, was eventually published in the Royal Astronomical Society's Memoirs in 1879[56] - the so-called Eclipse Volume - in which all eclipse reports from 1860 until 1878 (including manuscripts lodged with the Royal Astronomical Society) were assembled and edited[57]. Astronomers were disappointed that this publication should have taken so long to appear: in Breen's case he did not live to see it.

After the eclipse, Breen spent some months in Switzerland pursuing his linguistic studies before returning to London in 1861.

4.5. London, the Last Years 1861–1866

Back in London, Breen's paper with Challis on Halley's Comet was communicated to the Royal Astronomical Society in 1861, and he himself was elected a Fellow of the Society in June 1862. He continued to study, frequenting the Reading Room of the British Museum, and set out to devote himself seriously to



THE

PLANETARY WORLDS:

THE

TOPOGRAPHY AND TELESCOPIC APPEARANCES

OF THE

SUN, PLANETS, MOON, AND COMETS.

BY JAMES BREEN,

OF THE CAMBRIDGE OBSERVATORY.

WITH NUMEROUS ILLUSTRATIONS.

LONDON:
ROBERT HARDWICKE, 26, DUKE STREET,
PICCADILLY.
1854.

Fig. 2. Title page of James Breen's popular book.

writing. He contributed popular articles on astronomy, mostly anonymously, to newspapers and periodicals.

Breen's main work was to be a treatise on *Stars Clusters and Nebulae* to be published by the publisher of his earlier book. He had already completed the greater part of it - indeed printing had already started - when he was stricken by tuberculosis. He died on 25 August 1866 at the age of only forty, and is buried in Nunhead Cemetery next to his father.

5. JOHN WILLIAM BREEN

The astronomical career of John William, the youngest of the Breens, was the least eventful of the four. He was taken on as a computer at the Royal Observatory at the age of 14 in 1846, two years before his father's death, probably working under the superintendence of his brother Hugh. From 1849 onwards he progressed to occasional observing duties with the meridian instruments. Like all the family, John William was a hard worker: Airy once said that he wished he had more like him[58]. However, promotion eluded him. Being responsible for his widowed mother in "her increasing age and declining strength" he badly needed to improve his financial position[59]. In 1852, aged 20, and again in 1853, he asked to be considered for the job of Assistant when vacancies arose through deaths, but in each case someone else was preferred[60]. Six years later, his brother Hugh now gone, prospects were no better; John William was told that, if he needed a greater income, he should look for employment outside the observatory[61] - a path followed by many of the young Greenwich computers in the 19th century. This in fact he did; he obtained employment in a mercantile firm in

London and resigned from his post at the Royal Observatory on 7 January 1860[62] at the age of 28. It was the end of the long connection between the Royal Observatory Greenwich and the Breen family of Armagh.

John William Breen died, aged 38, in 1871 and is buried in the family plot at Nunhead Cemetery.

6. DISCUSSION

The story of the Breen family, besides its human and local historical interest, provides examples of careers in astronomy made or at least attempted in the nineteenth century when paid employment was rare and much of the day-to-day work in observatories was done by non-university educated assistants. Allan Chapman in his recent history of the Victorian amateur astronomer[63] devotes a chapter to the part played by such workers, among them the Breens, in British observatories. Our account of the individual lives of the members of that family will, we hope, add to that general picture of astronomy and astronomers in that important era.

We suggest, too, that the labours of Hugh and James, enthusiastic recorders of comets, merit further attention.

Acknowledgements

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31. Peadar Livingstone, 1969. *The Fermanagh Story, a Documented History of the County Fermanagh.* Cumann Seanchais Chlochair, Enniskillen.
32. Correspondence between Airy and Mrs C. Wicks, February 1859 (RGO6/4:133,151-152).
33. Paterson op cit.
34. Occasional discussions with the Astronomer Royal on the subject of computation are recorded between 1861 and 1864. In 1864 he applied to the Astronomer Royal for money as payment for the Planetary Reductions (RGO6/26).
35. Hugh Breen, 1863. *On the constant quantity of the moon's equatoreal parallax as deduced from observations made at the Cambridge Observatory, the royal observatories of Greenwich, Edinburgh and the Cape of Good Hope.* Memoirs of the Royal Astronomical Society, 32.
36. Hugh Breen, 1868-69. Royal Society Proceedings, 17, 344-346. Appendix to Greenwich Observations 1868.

37. Obituary, 1867, MNRAS, 27, 104.
38. J. McKee, 1982. *The Choral Foundation of Armagh Cathedral 1600-1870.* Thesis, Queen's University of Belfast.
39. Agnes M. Clerke's notice in the Dictionary of National Biography states that he was engaged as a calculator at the age of 16.
40. Airy to Challis, 30 June 1846. Cambridge Observatory correspondence.
41. Robert Main to Challis, 15 August 1846. Cambridge Observatory correspondence.
42. James Breen to Professor Challis, 8 August 1846. Cambridge Observatory correspondence.
43. F. J. M. Stratton, 1949. History of the Cambridge Observatories, Annals of the Solar Physics Observatory Cambridge, Volume 1. James Breen is listed as Senior Observer, 1846-58.
44. H. M. Harrison, 1994. *Voyager in Space and Time. The Life of John Couch Adams, Cambridge Astronomer.* The Book Guild, Lewes. The correspondence, with dates, between the great men about the new planet is reproduced in this book.
45. F. J. M.Stratton, op cit.
46. Hugh Breen to Challis, 4 September 1846. Cambridge Observatory correspondence. There are 5 letters from Hugh Breen to Professor Challis written between 1846 and 1858 in this correspondence.
47. Hugh Breen to Challis, 17 January 1858. Cambridge Observatory correspondence.
48. Obituary, 1867 (note 37).
49. James Breen, 1852, *Elements of Peterson's Third Comet*, MNRAS, 10, 155; ditto 1852. *Elements and Ephemerides of Brorsen's Comet of 1851*, *Astronomische Nachrichten*, 786.
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57. J. L. E.Dreyer *et al.*, 1987. *History of the Royal Astronomical Society Volume 1, 1820-1920*, (Reprint), Blackwell, Oxford, p.171.
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59. J. W. Breen to Airy, 24 May 1852 (RGO6/3:12,67).
60. Airy to J. W. Breen, 28 April 1853 (RGO6/96).
61. Airy to J. W. Breen, 31 May 1859 (RGO6/3:12/69).
62. Main to Airy, 7 January 1860 (RGO6/30:225-226).
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