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Observatory under Leuschner played its great part in the development of astronomers and astronomy in the United States.

Then suddenly and quite unexpectedly, Keeler died in San Francisco on August 12, 1900. And so the most prominent scientist of the first staff passed into history. His reputation as one of America's great astronomers is as high today as it was on the day of his death. And with this sad event, which was felt by all, here on the mountain and everywhere in the astronomical world, this part of the Short History of Lick Observatory comes to an end. Within a few days after Keeler's death, Campbell was elected director. His long career as administrator and his well-known astronomical success are too recent to be spoken of as history.

LICK OBSERVATORY, MT. HAMILTON, CALIFORNIA.

Alexander Wilson, M.D.*

A University Astronomer of Eighteenth Century Scotland

By ANGUS ARMITAGE, F.R.A.S.

During the eighteenth century there occurred in Scotland a cultural revival which bore fruit over wide fields of thought and practice. The Union with England in 1707 brought a growing measure of trade and prosperity to the northern kingdom and widened its intellectual horizon. As the century drew on, there shone forth in the Scottish firmament such bright stars as Colin Maclaurin the mathematician, David Hume the empirical philosopher, Adam Smith the founder of political economy, James Hutton the pioneer of modern geology, John Hunter the anatomist, Joseph Black the discoverer of specific and latent heats, and James Watt the improver of the steam-engine. These men exemplified only a few aspects of a rich and complex movement. Most of them, at some time or other in their lives, were connected with the old College of Glasgow, which, along with the other Scottish Universities, was at this period only just emerging from a largely mediaeval condition of things. The practice still survived of putting a class of students under the tuition of a *regent* who was expected to take them through their whole course in all subjects up to graduation level. But now this system was giving place to the modern practice of entrusting the teaching of each subject to a specialist professor. The circumstances which led up to the establishment of a Chair of Practical Astronomy at Glasgow, and the career of its earliest occupant, Alexander Wilson, are of some historic interest. Wilson was not of the intellectual stature of his great contemporaries above named, but he has some claim on our attention through his preoccupation with two matters much in the thoughts of astronomers today—the nature of sunspots, and the revolution of the stars about a common centre.

*Ninth paper in the series "Papers on Historical Astronomy."

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Alexander Wilson was born in 1714 at the Scottish University city of St. Andrews, where his father, Patrick Wilson, was town clerk.[1] Entering college young, as the custom then was, he excelled in the traditional branches of learning, and graduated M.A. of St. Andrews at the age of eighteen. However, he also found time to cultivate a taste for physical science, particularly astronomy and optics, and he managed to acquire, almost unaided, considerable skill in drawing, engraving, and modelling. Having chosen medicine as a profession, Wilson was apprenticed to a local surgeon and apothecary. About this time George Martine (a physician whose experiments on heat stimulated the researches of Joseph Black) encouraged him to take up glass-blowing as a hobby and to become proficient in making and graduating accurate thermometers. Wilson contrived to make these instruments easier to read by flattening the bore of the tubes so that the mercury appeared as a broad ribbon.

Already in those days many Scotsmen were taking the road to England in search of fortune, and quite a number of the fashionable London doctors hailed from north of the Border. In 1737 Wilson himself migrated to the English metropolis; there he found employment as assistant to a French surgeon, a political refugee, who received him into his family circle. Among the Scottish colony in London, Wilson found a friend in Dr. Charles Stewart, who was the private physician of Archibald Campbell, Earl of Islay, the brother and heir of the Duke of Argyll. Stewart introduced Wilson to Lord Islay himself, who ininvited the young Scotsman to see his fine collection of astronomical instruments, accepted several thermometers from him, and, as we shall see, subsequently played a decisive part in opening the way for him to become a professional astronomer.

However, the next stage in Wilson's varied career was determined by a chance visit which he paid to a London type-foundry. What he saw there suggested to him the possibility of improving upon the existing method of manufacturing metal types.[2] He shared his ideas with a fellow-townsman named Bain, and the two young men threw up their professions and went into partnership to exploit the invention, first in London and later at St. Andrews, where they established a type-foundry. They ran into unexpected difficulties, and were forced to revert to the traditional technique of type-making. The business flourished; a larger factory was erected near Glasgow, and a branch was opened in Dublin, of which it was decided, by a throw of the dice, that Bain should take charge while Wilson remained in Scotland. At that period the Glasgow University Printers were Robert and Andrew Foulis, who were to achieve lasting renown for their craftsmanship. It was not long before Wilson was brought into business relations with the Foulis brothers, his artistic talents finding scope in the design and execution of Greek types for the magnificent editions of the classics which were then being published by the University scholars. In due

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course he became official type-founder to the College of Glasgow with premises in the old College buildings, which have now completely passed away. During his hours of leisure, Wilson indulged his boyish interest in astronomy, the foundry affording excellent facilities for alloying and casting metal discs which he ground and polished to furnish specula for small reflecting telescopes.

It was at this period that Wilson's scientific interests brought him into close friendship with a gifted young amateur, Thomas Melvill, of whom there might have been much more to tell if early death had not removed him. In 1748 and the following year Melvill was up at St. Andrews taking a divinity course, and he co-operated with Wilson in a variety of scientific ventures, notably in investigating the temperatures of the atmosphere at what were then regarded as great heights above the Earth's surface. In those days there were no sounding-balloons with self-recording instruments; so the two investigators sent up a long train of kites attached to one another in a series by lengths of string. To the uppermost kite (which was often lost to view in the clouds) a thermometer was attached; this was released by means of a time-fuse at a prearranged instant, and it fell to earth (its fall being broken by an attached tassell of paper) where its indication was hastily read, and the low temperatures supposed to prevail at such altitudes were thus confirmed.

Melvill was stimulated by his friendship with Wilson to undertake various other researches. He deserves to be remembered as a pioneer of spectrum analysis.[3] Observing through a prism an aperture illuminated by incandescent sea-salt, he noticed that the image was sharply formed in yellow light: "Because the hole appears through the prism quite circular and uniform in colour, the bright yellow which prevails so much over the other colours must be of one determined degree of refrangibility,"[4] being, as we now know, the characteristic radiation of sodium. Melvill went on to suggest that differently coloured rays of light might travel at different speeds even through empty space, and suffer different degrees of aberration, forming, in fact, a sort of *aberration spectrum.* From the same cause, the eclipse of a satellite of Jupiter should be attended by colour-effects, the object appearing just before extinction in the colour which takes the longest time to reach us—a phenomenon which the contemporary astronomer James Short sought for in vain.[5] Melvill died in December, 1753, at the age of twenty-seven; he thus missed seeing his friend enter the ranks of professional astronomers, which came about through circumstances now to be related.

At Glasgow University, astronomy was studied as a branch of physics (or natural philosophy) by candidates for the M.A. degree. Several telescopes were available to the students for practical work, one of them, an eight-foot refractor, having been acquired in 1693. However, in 1757, a new chapter opened with the founding of an observatory to house and utilize a valuable collection of astronomical in-

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struments which had been bequeathed to the University by one Alexander Macfarlane, a wealthy Jamaica merchant.[6] The Macfarlane Observatory was erected in the grounds of the old College, and the instruments were installed there after having been first put in order by James Watt in his capacity of mathematical instrument maker to the University. Tobias Smollett the novelist, an old Glasgow medical student and a friend of Macfarlane's brother, refers to the observatory and its stock of instruments in his "Humphrey Clinker." Through the good offices of Wilson's old friend, formerly Lord Islay, who, in 1743, had succeeded to the title of Duke of Argyll, a Chair of Practical Astronomy was in 1760 established by royal warrant, and Alexander Wilson was chosen as its first occupant and as Director of the new observatory. Shortly afterwards he was awarded the honorary degree of M.D. by his old University of St. Andrews. He handed over the type-foundry to his two eldest sons under whom it prospered. At the observatory Wilson continued his efforts to improve the reflecting telescope, particularly by choosing a suitable metallic alloy for the composition of the speculum, and by giving to the latter a paraboloidal figure.

Wilson possessed almost perfect eyesight, and his trade had taught him to appreciate fine details of design. He was drawn to study the behaviour of sunspots, and to formuate the theory of their structure with which his name is usually associated in the text-books, and which he explained in a paper read before the Royal Society in April, 1773.[7] At that period it was the practice to observe sunspots by projecting an image of the Sun on to a white screen; but Wilson scrutinized them directly through a telescope provided with a dark glass.

It was in November, 1769, while observing day after day an unusually large spot, that Wilson noticed the progressive contraction, and eventual disappearance, of the penumbra (the shaded border) of the spot on the side nearest to the center of the solar disc, as the spot approached the western limb of the Sun. At the same time the umbra (the dark nucleus) was seen to contract in a characteristic manner and finally to disappear. He formed the opinion that "the central part or nucleus of this spot was beneath the level of the Sun's spherical surface; and that the shady zone or umbra" (what we call the *penumbra*), "which surrounded it, might be nothing else but the shelving sides of the luminous matter of the Sun, reaching from his surface in every direction down to the nucleus; for, upon this supposition, I perceived that a just account could be given of the changes . . . above described . . . and further, that the sudden alterations now discernible in the figure of the nucleus were occasioned by some part of it also being hid by the interposition of the edge of the excavation between the nucleus and the eye."[8] Wilson was confirmed in his opinion by observing that when the same spot appeared again at the Sun's eastern limb the following month, it was now the turn of the *western* side of the penumbra (nearest the centre of the disc) to be invisible. He drew further support

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from the observed behaviour of other spots in subsequent years, and he even sought to deduce geometrically from his observations the depth of the excavation constituting the spot. He concludes his paper with several Queries: "Is it not reasonable to think that the great and stupendous body of the Sun is made up of two kinds of matter, very different in their qualities; that by far the greater part is solid and dark; and that this immense and dark globe is encompassed with a thin covering of that resplendent substance from which the Sun would seem to derive the whole of his vivifying heat and energy?"[9] A spot might then result from the removal of part of this luminous covering through the working of some sort of gas generated within the dark globe. Wilson also expounded his theory in a prize Latin essay which was crowned by the Royal Academy of Science of Copenhagen in 1772.

In his memoir on sunspots of 1776, Lalande, the great French astronomer, objected that the changes observed in the appearance of a spot as it crossed the Sun's disc did not invariably accord with Wilson's theory.[10] He preferred to regard the nucleus, or umbra, of a sunspot as a dark, solid mass projecting from the flux of liquid, fiery matter covering the surface of the Sun, just as a rock projects from the sea at low tide; the penumbra then represented the surrounding shallows.

In the course of his reply to Lalande,[11] Wilson described how he had constructed a model of the Sun consisting of a spherical core of wood with a coating of glue and whiting in which he had cut sunspot cavities and blackened their floors with ink. He used to view this model from a distance, measuring up the spots and their penumbras with a micrometer as the sphere was slowly turned round upon a metal axle.

It long remained a matter of dispute, even among highly experienced observers of sunspots, whether their results afforded any significant support to Wilson's hypothesis. The generally accepted modern view of the typical spot as a shallow, funnel-shaped depression is, of course, related to an entirely different conception of the physical nature of sunspots from that prevailing in the eighteenth century.

In the same year, 1769, in which Wilson observed the great sunspot, there occurred an historic transit of Venus. Wilson and his Glasgow colleagues prepared to time the passages of the planet across the Sun's limb. For fear the smoke of the city should spoil the observations "an advertisement was put in the newspaper, begging the inhabitants, in cases where it would not be very inconvenient, to put out their fires from three o'clock that afternoon till sun-setting; the politeness of the inhabitants of Glasgow in complying with this request was far greater than could well be expected."[12] However, the numerical results exhibited a discouraging diversity owing to unexpected optical complications which were to become only too familiar to observers of such transits. In a later volume of the *Philosophical Transactions*[13] Wilson suggested a method of minimizing the effective thickness of micrometer wires, etc., in telescopes, namely, by taking lengths of the thinnest silver wire

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obtainable, flattening these under pressure, and then attaching them in the focal plane so that they were presented edgewise to the observer's eye. This, like all Wilson's other contributions to the *Transactions,* was "communicated" to the Royal Society by Nevil Maskelyne, the Astronomer Royal, with whom he corresponded extensively.

Early in 1777 Alexander Wilson and his son, Patrick, found themselves discussing why the stars do not fall on to one another under their mutual gravitation. Their conclusions were published later the same year (as "hints," not as a "rash hypothesis") in a short, anonymous pamphlet.[14] Wilson's way of solving the problem was to propound another: What hinders the planets from falling together to form with the Sun a single central mass? The solution obviously lay in the "projectile forces" of the planets which maintain them in "periodical motion" about the central luminary. Wilson invoked the same agency to account for the preservation of the system of the stars: "If Periodical Motion seems thus necessary to the preservation of a small assemblage of bodies, and if Newton's law presents to us the whole Host of Heaven as one great assemblage affected by gravitation, it seems necessary still to have recourse to Periodical Motion in seeking after the establishment of this Grand Universal System." May not then the Sun and his train be regarded as "but a faint representation of that Grand System of the Universe round whose centre this Solar System of ours, and an inconceivable multitude of others like to it, do in reality revolve according to the Law of Gravitation?" Both reason and analogy support this view, but "appeal may be made to arguments still more direct," namely, to the proper motions of stars announced by Halley in 1718 and confirmed by other astronomers. As if foreseeing the achievements of Lindblad and Oort, Wilson concludes: "Let posterity therefore determine how far the observed laws of these celestial motions shall favour these hints of One Grand Universal System." Were it not for the periodical motion of the stars about a common centre, "the whole glory of Nature would terminate in one universal ruin. But a supposition so injurious to the wisdom and to the over-ruling power of the Deity must be rejected as derogatory in the highest degree."

It is of interest to compare these words with those of another minor astronomer of the eighteenth century, Thomas Wright of Durham, in his "Original Theory," published just two hundred years ago.[15] Wright speaks of "the projectile, or centrifugal Force, which not only preserves [the stars] in their Orbits, but prevents them from rushing all together, by the common universal Law of Gravity," etc.[16] Was Wilson acquainted with Wright's little-known work published twenty-seven years before his own? Even Sir William Herschel makes no reference in his writings to the pioneer work of Wright; and he seems not to have seen Wilson's tract until he received a copy from the author only a few days before his own classic paper "On the Proper Motion of the Sun and Solar System" was read (March 6, 1783) to the Royal Society. Her-

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schel acknowledged the gift in a letter to Wilson dated March 3, 1783. Addressing the Glasgow astronomer as "a Gentleman so dear to all lovers of science and to Astronomers in particular," Herchel continues: "I was apprehensive that what I had wrote on the motion of the Solar System might be thought too much out of the way to deserve the notice of Astronomers; but since I have seen the contents of the valuable tract you have sent me, I am not without hopes that what I have said will be received, by a few at least, with no disapprobation; and if you should be one of that number, I shall think myself particularly flattered."[17] Herschel also referred to Wilson's tract in a note appended to his paper when it was printed in the *Philosophical Transactions* of 1783.

It was in that same year that Alexander Wilson resigned from his Glasgow Chair owing to advancing age, and was succeeded by his son and assistant, Patrick Wilson (1743-1811). The veteran astronomer lived in retirement among his family for three more years, and passed peacefully away on October 16, 1786. Herschel found in Patrick Wilson a faithful friend and correspondent. After Patrick, in his turn, had relinquished the Glasgow Chair in 1798 and settled in London, he and his sister were welcome guests of the Herschels at Slough, where the two astronomers amicably observed sunspots together.

Meanwhile, the useful activities of the old Macfarlane Observatory continued to the middle of the nineteenth century. It was there that William Thomson, later Lord Kelvin, learned to take star-transits. However, by that time, the site was becoming hemmed in with high buildings, and the atmosphere polluted by smoke. Accordingly, in 1845, the authorities took over an observatory founded some years before by a private society at Horselethill, which at that time lay some way out from Glasgow but now forms part of the western suburbs of the city. Thither the instruments were transported, and there the astronomical work of the University is still carried on.

References

[1] An obituary of Wilson was read before the Royal Society of Edinburgh in 1789 by his son and successor, Patrick Wilson; it was published much later in the *Transactions* of that Society (1826, x, 279 ff.).

[2] T. C. Hansard: *Typographia*, London, 1825, pp. 362 ff.

[3] *Essays and Observations, Physical and Literary*, read before a Society in Edinburgh and published by them, Vol. ii (1766), pp. 12 ff. Reprinted in full in *Journal of the Royal Astron. Soc. of Canada*, 1914, viii, 229 ff.

[4] *op. cit.*, p. 35.

[5] *Phil. Trans.*, 1753, xlviii, 268 ff.

[6] See D. Murray: "Memories of the Old College of Glasgow," Glasgow, 1927, pp. 260 ff.

[7] *Phil. Trans.*, 1774, lxiv, 1 ff.

[8] *ibid.*, p. 8 f.

[9] *ibid.*, p. 20.

[10] *Hist. de l'Acad. Roy. des Sciences, Année* 1776 (1779), *Mém. de Math. et de Phys.*, pp. 457 ff.

[11] *Phil. Trans.*, 1783, lxxiii, 144 ff.

[12] *Phil. Trans.*, 1769, lix, 334.

[13] *Phil. Trans.*, 1774, lxiv, 105.

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