John Aitken, LL.D., F.R.S. By C. G. Knott, D.Sc., LL.D., F.R.S.

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JOHN AITKEN, born at Falkirk on September 18, 1839, was the fourth son of Henry Aitken of Darroch, Falkirk, head of a well-known legal firm in that town. He was educated at the Falkirk Grammar School and the University of Glasgow, where he studied with a view to a career as an engineer. Two years of his apprenticeship he served in Dundee, and three years with Messrs Napier & Sons, shipbuilders, Glasgow. After finishing his apprenticeship as a marine engineer he broke down in health, and was compelled to abandon all thought of carrying out his profession. Thenceforward his interest lay in the line of scientific and especially physical research, for which he received a great inspiration while attending Lord Kelvin's (then Sir William Thomson's) classes in natural philosophy.

His early training as an engineer was of incalculable value all through the long series of physical investigations which made his name famous in the ranks of experimenters. Most of the apparatus used in his researches was not only devised by him but constructed with his own hand. The drawing-room of the house he occupied latterly in Falkirk was transformed into a laboratory and workshop, with a fine turning-lathe placed in front of the window and supplied with all kinds of tools of the most approved pattern. A carpenter's bench and work-tables laden with glass-work, blowpipes, and many odds and ends of apparatus in the course of construction or of apparatus which had served its purpose, covered the floor space, while cabinets along the walls contained drawers full of thermometers and other delicate meteorological instruments.

The earliest line of work which brought out his experimental skill was a discussion of colour sensations in a paper read before the Royal Scottish Society of Arts in 1872. He devised new methods of experimenting, and elaborated a modified form of Young's three-colour theory of sensation, supporting it by means of many ingenious experiments. Another early line of thought led him to discuss the conditions of boiling of liquids and condensation of vapours, which he showed to depend on the presence of free surfaces separating different states; and it was by following up some of the ideas suggested by this work that he hit upon what will probably be regarded as his greatest contribution to physical science. This was the demonstration that water vapour in the atmosphere will not condense to

form clouds unless it has some solid or liquid nucleus to condense upon.* Dr Aitken worked out this whole research with unswerving zeal, clearing away by a magnificent series of control experiments many objections which seemed at first sight difficult to meet and even inconsistent with the broad theory. He brought into prominence the vast importance of the dust in the atmosphere, not only visible dust but the impalpable dust particles which provide nuclei for the condensation of vapour and the formation of visible drops of rain or mist. By an interesting process of evolution he gradually constructed a form of apparatus by which, from the number of raindrops produced in a closed region of saturated air, he was able to calculate the number of dust particles in this region. A slight expansion by means of an air-pump in connection with the closed region produced a cooling in the saturated air, from which the vapour condensed on the dust particles and formed tiny drops of water. These, falling on a silvered surface ruled in small squares, were readily counted. This was the so-called Dust-counter, the final portable form of which was an instrument of considerable precision in the hands of the skilful meteorologist.

The production of a fog cloud in a receiver from which saturated air was being extracted was a phenomenon which had often been seen by experimenters; but it was reserved for John Aitken not only to give a complete explanation of the phenomenon but to open up an entirely new line of research.

Aitken's experiments proved that when the saturated air was free of dust no cloudy condensation took place on slight expansion, for there were no particles to serve as nuclei. He found, however, that once the air was cleared of dust by filtration through cotton-wool, a more rapid expansion sometimes led to cloudy condensation. The explanation of this was subsequently given by C. T. R. Wilson, who showed that ionised air, although dust free, produced cloudy condensation when a considerable expansion with accompanying cooling took place. There has consequently been a tendency in some quarters to explain condensation of vapour in terms of the presence of ions, arguing that Aitken's dust particles were unnecessary as a factor in the process. But such a view shows an absolute lack of appreciation of the whole meaning of the phenomenon. The sudden expansion and cooling required to produce cloudy condensation on ions are much greater than can ever occur in nature. On the other hand, when dust particles are present a very slight expansion with accompanying slight

* See "On Dust, Fogs, and Clouds," *Trans. Roy. Soc. Edin.*, xxx, 1880–1 ; and various papers on dust particles in the air, *Trans. Roy. Soc. Edin.*, vols. xxxv to xxxix, 1887–1899; and many papers in the *Proceedings*.

cooling suffices. An experiment often made is to hold a bunsen flame for a moment within a receiver, set the receiver immediately on the air-pump plate with a dish of water within it, and then pump some of the air out. A dense fog cloud is formed, and this is not unfrequently referred simply to the ionisation due to the flame. But the argument is faulty, for of course there are numerous dust particles also produced by the flame, and it is impossible in such an experiment to discriminate between the effect of the particles as fog producers and the effect of the ions. Moreover, Aitken himself proved that when dust particles were undoubtedly present electrification of the air did not increase the cloudy condensation.

When we recognise that dust particles are always present in the atmosphere, and that a slight cooling of the saturated air is the cause of the production of raindrops, and when we further bear in mind the beautiful demonstration given by Aitken that no cloudy condensation is produced in saturated dustless air on slight cooling, there is no escape from the conclusion that mist, fog, and cloud require for their formation the presence of dust particles.

Another important direct result of Aitken's experiments on cloudy condensation, and especially of his methods of counting the raindrops formed, is worthy of mention. Sir J. J. Thomson in his classical experiments on the mass and charge of an electron made use of Aitken's method of condensation in obtaining one of the measurements on which the determination of these two small quantities depended.

Meanwhile, Aitken himself pushed his own investigations in many directions, such as the meteorological and industrial conditions governing the production of dust particles in the air, the influence of locality and altitude, the effect of prevalent winds and of cyclonic and anticyclonic distributions.

Closely connected with this whole research is his important paper on the formation of dew.* His views, though now generally accepted, were strongly combated by certain authorities at the time of their first promulgation. What he showed by skilfully arranged experiments was that the vapour which condenses as dew on cold surfaces comes mainly, if not entirely, from the ground below and not from the air above. He also showed that the so-called dewdrop on leaves of plants was not dew at all, but was exuded sap. He has also placed on record some interesting observations on hoar frost; and in a paper published in the *Journal of the Scottish Meteorological Society* he has given a remarkably clear description of the formation of ground ice.

In his presentation of papers before our Society, in whose *Transactions*

* See "On Dew," *Trans. Roy. Soc. Edin.*, xxxiii, 1885.

and *Proceedings* his most important work is published, Dr Aitken spared no pains in bringing before his audience the very experiments he had devised in following out his ideas. Thus he imitated on a large experimental scale the production of cyclones and the manner of their trend over the earth's surface.* Whether, in view of the new information we have in regard to the vertical distribution of temperature in cyclonic and anticyclonic distributions, Aitken's own views as to the genesis and maintenance of cyclones will continue to meet with acceptance, it is perhaps too soon to give a judgment. He himself believed that apparent discrepancies could be explained, and his latest paper on this subject, published in the *Proceedings* of the Royal Society of London, discusses many of the physical relations in an interesting and profound way. In this kind of work, however, he was handicapped from lack of mathematical equipment.

With a mind keenly alive to all problems of a meteorological character, John Aitken entered in 1884 upon a long series of experiments on the measurement of air temperatures. In the majority of our meteorological stations the thermometers are placed within what is known as the Stevenson screen. This form of screen was long ago found to be quite unsuitable for hot climates, and in India the thermometers are placed under a broad shed through which the air courses freely. Aitken soon satisfied himself that in this country also the temperature given by thermometers hung within the Stevenson screen read several degrees too high when the day was fine and sunny. After many experiments on various forms of screen, he finally devised a form free from the defects of the Stevenson screen, and incidentally made many other interesting and important observations on temperatures of air and soil and solar radiation. At his death on November 14, 1919, he left in manuscript what might be called his matured views after thirty years of experimenting, wherein he lamented that meteorologists still continued to use a demonstrably inefficient method of screening the thermometer from the effects of radiation, direct and indirect. This paper has been published in the *Proceedings* of the Royal Society of Edinburgh, and it may well be regarded in the light of a scientific legacy from a great natural philosopher.

The bulk of his estate Dr Aitken left in the hands of trustees to use (1) for the benefit of the poor of Falkirk; (2) to establish a temperance public-house in Falkirk. He also left a fund of £1000 to the Council of the Royal Society of Edinburgh to meet the cost of publication of a collected edition of his more important papers. This is now being prepared.

* See "Notes on the Dynamics of Cyclones and Anticyclones," *Trans. Roy. Soc. Edin.*, xl, 1900; also *Proc. Roy. Soc. Edin.*, xxxvi, 1916.

I have touched only on the outstanding problems which Aitken tackled and solved; but his many papers on physical subjects show that he possessed in a singular degree the power of clear thinking and a real intuition for the devising of illustrative experiments. His one aim was to get at the truth. He was severely critical of his own experiments, making sure at every step that all precautions had been taken against possible flaws of adjustment or fallacies of reasoning. He was never satisfied until a clear issue was established. Thus for many years he was unable to find a convincing explanation of the great increase in the number of dust particles at certain times of day at Kingairloch, a small holiday resort on Loch Linnhe, to the south of Fort William. Time and again he returned to the inquiry; and at length he was rewarded by the discovery that the source of the particles was the foreshore under action of the rays of the sun at certain conditions of tide.*

After the publication of his great paper on Fogs and Clouds, Aitken was recognised as one of the original experimenters of his day. In due course he received honours and medals from various scientific societies, including the Keith and Gunning Prizes from the Royal Society of Edinburgh, and a Royal Medal from the Royal Society of London. In 1899 he received the degree of Doctor of Laws from the University of Glasgow.

Much though his friends desired it of him, Aitken would never accept office as president or vice-president in the societies to which he brought credit and renown. To the end he remained the same quiet, modest investigator, keenly interested in all true scientific progress, and never accepting any theory which seemed to him insufficiently supported by physical reasoning. Every problem which presented itself was studied in his own way and by his own methods, and to him in a peculiar sense we might well apply the Horatian line from which the Royal Society of London has taken its motto—

"Nullius addictus jurare in verba magistri."

Handicapped through his long life by ill-health, but blessed with a competency which made him independent, John Aitken was fortunate in being able to cultivate his inborn powers undistracted by official duties. Still more fortunate the country which could claim him as one of its distinguished sons.

* See "The Sun as a Fog Producer," *Proc. Roy. Soc. Edin.*, xxxii, 1912.