Wilson of the Cloud Chamber – broadcast in 1959

Introduction

Our historical scientific instrument collection at the University of Aberdeen includes more than just instruments, for there are in addition instrument catalogues and manuals, invoices, photographs, slides, reprints of papers and drafts of talks, notebooks, in fact a selection of paraphernalia that one would expect to accompany University teaching and research. It is of course all relevant to staff interests over the decades and indeed the centuries. One area of staff interest has been atmospheric physics, from the low atmosphere of meteorology to upper atmospheric phenomena such as noctilucent clouds, the aurora and night-glow. Included in the collection are photographs, slides and papers at one time belonging to C T R Wilson, of whom I used to say he was the only Scot to have won the Nobel Prize in Physics. In 2016 he was joined by Michael Kosterlitz and David Thouless. This material nicely complements the Balfour Stewart Collection of documents relevant to atmospheric physics held in the University archives. (As well as the overlapping of scientific interest, Balfour Stewart had taught Wilson at Owens College, Manchester).

C T R Wilson is still famous for the invention of his cloud chamber and the discovery that it can be used to display ion tracks created by subatomic particles, enabling the particles themselves to be identified. The cloud chamber proved to be a key tool that led to other Nobel Prizes and helped unlock the mechanisms involved when ionising radiation dissipates its energy. We have in our collection two small cloud chambers made for teaching purposes and the kind of instruments that CTR would have used for his work on atmospheric electricity, such as a Dolezalek electrometer by the Cambridge Scientific Instrument Co.. Our own Nobel Prize winning physicist, G P Thomson, was a student of Wilson’s in Cambridge, which adds interest to the radio interview given by C T R Wilson for the Home Service that reviewed his life and work. The following is the script of the programme, courtesy of his daughter, the late Jessie Wilson, in which CTR on the occasion of his 90th birthday describes his own life and work. Later that year he wrote a more extensive ‘reminiscences of my early years’, covering the period up to 1900, that were published in Notes and Records of the Royal Society, vol. 14, No. 2, pp 163-173, 1960. He was interviewed for a second programme, for the BBC European Service, for which we also have a transcript. He died in November 1959.

John S. Reid

WILSON OF THE CLOUD CHAMBER

Transmission: Monday, 16 February 1959: 8 – 8.30 p.m.

ANNOUNCER : This is the Scottish Home Service. Last Saturday Professor C.T.R. Wilson, Companion of Honour and Fellow of the Royal Society, celebrated his 90th birthday. Professor Wilson is one of Scotland’s most distinguished
scientists and one of the world’s most famous physicists. To commemorate the event we present this programme, Wilson of the Cloud Chamber, introduced by Harry Hoggan.

HOGGAN: Charles Thomson Rees Wilson was born near Edinburgh on a farm in the Pentland Hills on St Valentine’s Day 1869. Forty years later he devised a new and revolutionary piece of apparatus, a Cloud Chamber, which Lord Rutherford described as ‘the most wonderful experiment in the world’. This apparatus has been – and still is – used in every physical laboratory in the world.

Today ‘C.T.R.’ as he is universally known, lives in retirement in the village of Carlops, outside Edinburgh, close to his place of birth. He is the most modest of men, so unassuming that many of his neighbours may be quite unaware that ‘C.T.R.’ is internationally recognised as one of the greatest physicists of all time.

Recently I visited Professor Wilson in his cottage at Carlops and talked with him about his work and his early days as a boy and a student.

WILSON: I was born at Crosshouse, a farm at the foot of Castle Law. My father was a farmer who kept sheep on the Castle Law hill and he had come from a race of farmers who farmed about the Biggar district. My father died when I was four and my mother went to live in Manchester where her parents and brothers had gone from Glasgow some time before. I went to school in Manchester, and when I was fifteen I went to Owens College which was then part of Victoria University. When I went to Owens College it was really with the intention of becoming a medical student but before doing that I studied science mainly in natural history and things connected with that. I took a degree there in zoology, geology and botany, but in the first year or two I did a certain amount of physics and chemistry. It was after taking my degree in mainly zoological subjects that I heard about the possibility of trying for an entrance scholarship in Cambridge, and I succeeded finally in getting an entrance scholarship to Sidney Sussex College. I was, as the Sidney Sussex people expressed it, picked out of Christ College waste paper basket; that is, I hadn’t entered as a candidate for a scholarship at Sidney but for one at Christ’s.

HOGGAN: So the young ‘C.T.R.’ who, but for the death of his father, might have become a Scottish sheep farmer, became instead a student of Science at Cambridge University. But to meet him, he might be mistaken for a sheep farmer: in fact he loves nothing better than to walk over his beloved hills – all his life he has been fond of climbing and knows intimately our Scottish mountains.

WILSON: After taking my degree in 1892, I continued in Cambridge for two years and

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1 Harry Hogan was a Glasgow University graduate, joined the BBC in 1936, elected FRSE in 1951 and was BBC Director at Aberdeen from 1959 – 1967. He died in 1982.
then I happened to hear that the authorities who looked after the observatory on the top of Ben Nevis, sometimes were glad to have the help of a young physicist to take the place of observers when they were on holiday. So I applied and spent a fortnight on the top of Ben Nevis in September 1894. I enjoyed my stay up there very much and saw many wonderful things. The things that interested me most were the remarkable cloud effects that one got when the sun was shining on the clouds below the hill top especially the glories that were formed round one’s shadow, round the Brocken spectre; that is when the sun was in the suitable position. The brightest of all these glories were formed when one stood on the edge of the great precipice of the facing of Carn Mor Dearg and, I believe, that is one of the best places for observing the glories, in existence.

HOGGAN: The glory, which Professor Wilson mentioned, is formed when your shadow is cast on a cloud. So you see it most often when the clouds are below you. The glory takes the form of coloured rings surrounding the shadow of your head – like a halo. It’s sometimes called the ‘Brocken Spectre’ after the Brocken Mountain in Germany where it’s often seen. The corona is a similar coloured ring round the sun or moon – and no doubt you’ve often seen it when a thin cloud passes of the face of the moon.

But to return to ‘C.T.R.’. When he got back to Cambridge – to the Cavendish Laboratory – he decided to try to find out what caused these glories. Now to do this he had to produce a cloud artificially in the laboratory, and he did this by the sudden expansion of moist air in a closed vessel. The expansion cooled the air so its moisture condensed into a cloud of tiny drops.

Now just about this time another Scot, John Aitken of Falkirk, had shown that condensation would only take place if very tiny particles were present in the air. (By the way, John Aitken was a remarkable man. He trained as an engineer but after a breakdown in his health he gave up his life to study condensation, using the sitting room of his house in Falkirk as his laboratory.) Well, these minute particles – now called condensation nuclei or Aitken nuclei – could be removed from the air, because each droplet forms round one of these particles and then falls slowly, under the force of gravity, to the bottom of the vessel.

‘C.T.R.’ then made a surprising discovery. He found that he could still produce a few droplets – after all the condensation nuclei had been removed – provided the expansion was great enough.

WILSON: It was as a result of seeing the glories and corona which are formed around the sun and moon, that I was led to my work on condensation of water vapour upon nuclei. When I came down I tried to, or intended to, make observations on artificially produced coronas and glories but, almost at once, I succeeded in coming across something much more interesting. I found that when all the dust particles, as Aitken called them or what we should now call Aitken nuclei, had been removed one still was able to produce condensation in the form of drops...
provided a certain quite distinctive degree of supersaturation was succeeded. That is a perfectly definite sudden expansion amounting really to a quarter of the original volume.

HOGGAN: So here was the very first cloud chamber experiment.

WILSON: Yes, one may call it a cloud chamber. It was very simple apparatus for subjecting a given volume of air to repeated expansions under conditions such that the entrance of dust particles from outside was excluded.

(Recorded) HOGGAN: Now since there were no normal particles of condensation present in the chamber, C.T.R. naturally wondered what was now causing the droplets to form. They always formed provided the expansion was great enough. The nuclei, therefore, must be freshly made, all the time, in the air.

Wilson made the correct guess. And the answer he got was breathtaking. He deduced that these nuclei were charged atoms – what were soon to be called IONS. And we know that these stray ions are produced by radioactive material in the atmosphere and by cosmic rays.

Indeed they’re produce by knocking an electron out of an atom. Now an atom is neutral; but if an electron, which is negatively charged, is knocked out then the atom is left positive. In this way, each time an electron is knocked out of an atom, a pair of ions is formed – one positive and one negative.

WILSON: I was very much interested in the comparatively small number of drops that have been got with a certain range of expansions between one point two five and one point three five, and I couldn’t help wondering what these few nuclei could be. They were obviously always being produced and, at a very early stage, I began to wonder if they could be charged atoms or what was very soon to be called ions, and that one was thus making visible the individual ions. These experiments, I may say, really led me to work that continued for the rest of my scientific life. On the one hand, I was naturally led to make further experiments on the action of these whole ions as condensation nuclei and, among other things, to compare the positive and negative ions in their behaviour in supersaturated air.

HOGGAN: Now just at this time Röntgen discovered X-rays, so C.T.R. exposed the air in the Chamber to these rays. With a sudden expansion he now got a dense cloud, instead of a few droplets. The reason? The X-rays were producing a multitude of ions in the air in the chamber – each of them serving as a nucleus for a water droplet.

WILSON: Yes, in 1896, very soon after the discovery of X-rays by Röntgen, I was able to use a primitive X-ray tube made in the Laboratory by Everett, Professor Thomson’s assistant, and I was delighted to find, on exposing the chamber to these rays, that I got a dense fog instead of the two or three drops still requiring this definite expansion to bring the nuclei on which the drops were formed, into
action. This in itself was sufficient to make it extremely likely that the condensation nuclei that I had been studying were ions, the ions to which the conductivity of a gas exposed to X-rays was attributed specially by J. J. Thomson and Rutherford who were working together at that time.

HOGGAN: Meantime a great deal of work was being done on alpha and beta particles – the particles that are emitted spontaneously all the time by radioactive substances. The beta rays are electrons. The alpha rays are huge by comparison and are the nuclei of helium atoms. Each particle travels with such great speed that as it rushes through the air, it ionises the molecules of air and leaves a track of ions behind it. Wilson now tried to make these tracks visible. His idea was to make water condense on the ions to form droplets before they had time to fall. In this way he hoped to show the path of those fast particles.

WILSON: Well, I should think about 1900 I began to think about the possibility of making these ions visible in the positions which they occupied immediately after they were set free and so getting the tracks of ionising particles like alpha rays and beta rays but it took us ten years before I produced the real cloud chamber suitable for making visible the tracks of ionising particles.

HOGGAN: That was in 1911, and the success of the experiment was greater than even C.T.R. himself expected. At the time Sir William Bragg was one of his students, and he has written “The time of the discovery of the tracks was a thrilling one. I can hear now Wilson saying ‘they are as fine as little hairs!’ And the photographs that Wilson took at this time have never been bettered, through tens of thousands of similar photographs have been made in laboratories all over the world. This original Cloud Chamber – one of the most famous pieces of apparatus in the history of physics – rests in the museum of the Cavendish Laboratory in Cambridge. A few years ago Sir Lawrence Bragg asked C.T.R. if this was the original Cloud Chamber. C.T.R. replied “But I never made but the one!”

WILSON: Yes, that actual cloud chamber made in the Cavendish Laboratory was the one I used in all my work on condensation nuclei on the tracks of ionising particles.

HOGGAN: Now, the discovery that ions – charged particles – are continuously being produced in the atmosphere, let C.T.R. to try to find if the air conducts electricity. His experiments proved that it did – and so he began to work on a new field of research – that of atmospheric electricity. He has said that that his interest in the subject really began as a result of his experience on Ben Nevis – or rather on Carn Mor Dearg (pronounced Jerrag) near by. One afternoon on a sultry day in June 1895 on the summit of Dearg, he heard the first mutterings of distant thunder. Shortly afterwards he felt his hair stand up. Immediately he ran down the scree to the corrie, just before a vivid flash of lightning and a peel of thunder. It was this experience that brought home to him the existence of enormous electric fields below a thunderstorm and to their sudden changes.
On his return to Cambridge he began investigating thunderstorms and the results of his research laid the foundation of atmospheric electricity and his theory of thunderstorms remains the most acceptable today.

**WILSON:** The fact that ions were produced normally in air as well as in air exposed to ionising particles, led on to researches in another line, that of atmospheric electricity. The first obvious thing to try was whether air under normal conditions did conduct electricity to a small extent and experiments of that sort were carried out somewhere in the region of the year 1900.

**HOGGAN:** It was no surprise when C.T.R. was awarded the Nobel Prize for Physics in 1927 – or rather it was no surprise to anyone except C.T.R. himself.

**WILSON:** I always remember my first knowledge that I’d got a prize. I had been rather troubled by someone who expected me to know all about a paper that he had written and who was very insistent I had just become a professor; I had become a professor in Cambridge by this time and he thought that I ought to have read his paper. He had left me rather late in the evening and I thought he’s sure to ring me up and pursue this subject; and, sure enough, the telephone bell rang but the message was from the Swedish Embassy in London to tell me that I’d got a Nobel Prize; and asked me, even then I think, whether I would be able to go to Stockholm to get it. I didn’t quite believe it at first. I wondered if I was hearing correctly and, however, next morning I got a more direct intimation that ended in me going to Stockholm to receive the prize.

**HOGGAN:** I asked C.T.R. if he had any feelings about the way atomic physics had developed – for these developments had largely been investigated by the use of the Wilson Cloud Chamber.

**WILSON:** Well, this is rather a difficult question to answer. At a very early stage, as soon as I got my first glimpse of clouds condensing upon tracks of ions, I knew that this method of making ions visible and making tracks of ionising particles visible, I knew that the method could not have helped being a very useful one in studying all sorts of ionising radiations and discovering new ones probably. It was natural that having got them and having got them much more well defined than I’d ever anticipated, it was natural that I should be more alert to the possibilities than most people.

**HOGGAN:** Then I asked him what he thought about recent developments in nuclear physics.

**WILSON:** I think the less I say about that the better. The physics and especially the physics of radiation of all kinds and of these particles, has gone so far that it has left me far behind.

**HOGGAN:** Nevertheless I remarked that he must have felt highly satisfied to have been ‘on the ground floor’ of these early developments and to have been associated with most of the famous physicists of the time.
WILSON (Recorded) Oh, naturally, I’ve had every satisfaction from that feeling. There has been, of course, the delight of actually seeing, for the first time, the successful working of a piece of apparatus but there has also been the satisfaction of knowing that the method has been used over the whole world now and the method has been so much improved by different observers that it has reached up to possibilities that I never thought of.

My memory of physicists goes back to last century and I’ve pleasant memories of my meetings with Stokes since, Kelvin besides, of course, my friends in the laboratory; J. J. Thomson and Rutherford and the younger people, the people of the next generation.

HOGGAN: The whole of C.T.R.’s work undoubtedly developed from what he saw during that fortnight at the Ben Nevis Observatory in September 1894. (The Observatory built and maintained by members of the Scottish Meteorological Society ceased to function in 1904 and it’s now in ruins. Nobody could have anticipated that it would have provided the opportunity for the conception of an idea that was to produce such vital results in the history of science.)

And it’s probably no exaggeration to say that atomic and nuclear physics had their beginnings on the summit of Ben Nevis during these September days 65 years ago.

But these were indeed memorable times in physics – especially at the Cavendish Laboratory at the turn of the century. J. J. Thomson had discovered the electron; Lord Rutherford was unravelling the secrets of radioactivity and Professor Wilson provided the instrument for the further study of the effects of these fundamental particles. In addition, he was making his investigations on the electricity of the atmosphere and creating the framework of our present day knowledge of the subject. He still maintains his interest in meteorology and I wasn’t surprised to discover that he flies regularly with members of the class of Meteorology at Edinburgh University. He signs the official R.A.F. flight forms as a ‘student of meteorology!’ Ninety not out! And a familiar figure with the airport staffs at Stornoway, Benbecula and Tiree in the Outer Hebrides.

But it’s for his Cloud Chamber that Wilson will always be remembered – an instrument that was used in laboratories all over the world. In particular one of his students, Professor Blackett (now Professor of Physics at Imperial College, London) has developed and adapted the Wilson Cloud Chamber to examine and make far reaching discoveries in cosmic rays.

Indeed many of Professor Wilson’s students have become famous in the world of physics, including Sir George Thomson, Sir Lawrence Bragg. And Sir Edward Appleton, now Principal and Vice-Chancellor of the University of Edinburgh adds this tribute to Professor C.T.R. Wilson.

1. APPLETON There was always for him a best way of doing anything, a most elegant way
and he was never satisfied until he had achieved it.

Now ‘C.T.R.’ never directed a large research team. That wasn’t his way. So the number of those who enjoyed the unique privilege of working with him has been small. And yet I expect that everyone of that small group would say that it’s been an even greater privilege to have enjoyed his personal friendship as all of us have done. Of course we know of his scientific fame and prestige, even though he himself is quite unaware of either. And he’s just as much our hero as anybody else’s. But he’s this much more to us: he’s the most loveable man of science we’ve ever known.

2. ANNOUNCER You have been listening to “Wilson of the Cloud Chamber” a programme to celebrate the 90th birthday of Professor C. T. R. Wilson, Companion of Honour and Fellow of the Royal Society. The postscript was given by Sir Edward Appleton, F.R.S., Principal and Vice-Chancellor of the University of Edinburgh.

The programme, which was recorded, was introduced by Harry Hoggan.