theory was hammered out. It was then that he had another of the great ideas that show his inventiveness and his concern for simple explanation of complicated subjects – the bubble model.

The idea occurred to him when he noticed the rafts of bubbles that formed when he mixed the oil for his motor mower. What a good illustration of a crystal of an element they would make if they were all the same size! He realized that it is easy to make bubbles of constant size; they must be blown from a narrow orifice under soap solution by a constant pressure. Crowe – Bragg's research assistant – and I fitted up the arrangement and showed that it worked quite well. It has helped innumerable students to get a first foothold on this extremely important subject.

I hope that I have painted a picture of a really great physicist who could not only make a difficult subject seem easy, but could teach it in such a way that others could make use of it. I would claim that there is no other man in recent years who attained leadership in his subject and kept it over so many years. It was a privilege to have worked under him.

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## Personal Reminiscences

BY J. THEWLIS

*The Mount, Ardentinny, by Dunoon, Argyll, Scotland*

I first met W. L. Bragg in 1922 as a student in the School of Honours Physics at Manchester University. He had then been Professor of Physics there for some three years and was, at the age of 32, very young as professors go. Indeed his youth was regarded with some pride by his students and the story was told, with an air of triumph, of how he had, on at least one occasion, played centre-forward for the Departmental hockey team.

By modern standards the Department was small. There was only one professor, but, in consequence, the students were known personally to him and were not mere names. Indeed he took a deep interest in his students' careers; and I shall always remember the fatherly talk he gave to me at the end of my first year when, like many others before and after me, I had found University life too interesting to leave room for very much work.

As a research student I came to realize that Professor Bragg was actively behind all the work being carried out in the now famous Manchester School of X-ray crystallography. Bragg himself was then pursuing his study of the silicates with its significance for the study of ionic radii, optical properties and modes of packing, James his intensity work, and Bradley his work on the structure of alloys from X-ray powder photographs, work with which I was myself associated, particularly in the elucidation of the structures of $\gamma$-brass and $\alpha$-manganese. Brentano, the only other powder worker (the rest being concerned with single crystals), was working on the technique of focusing in powder photography and E. J. Williams had recently arrived to make his distinctive theoretical mark. But in a chapter of reminiscences it is, perhaps, not so much the scientific work as the people that are of interest. E. J. Williams I remember for his vitality and exuberance – there was then no hint of that disease which led to his tragically early death during the war. He was the moving spirit in a group of table tennis enthusiasts who used to play on the library table out of hours, a table which was vastly beyond regulation size and made for some heroic games. James I remember for his absolutely first class lectures to his students, and for his part in Shackleton's Antarctic Expedition, about which one could manage to get him to talk only rarely. He also, on one occasion, exhibited an unexpected gift as an actor, when at a Departmental party he surprised everybody from Bragg downwards by playing the part of a bearded German professor who had invented an 'ultra-ultra-microscope' which revealed individual atoms marching about with, I rather think, clogs on their feet.

Bradley was remarkable for his powers of concentration, his intuition in matters of structural arrangement, his amazing absent-mindedness, and his theories about life in general. We worked with a home-made X-ray tube held together with sealing wax and evacuated by a primitive mercury-in-glass distillation pump backed by a Gaede oil-pump, backed in turn by a hand-operated pump of unknown origin. When the tube got too hot the sealing wax would melt and the whole filament assembly would gradually be sucked towards the target – ability to detect leaks and skill with a small flame and a stick of wax were just as important as the ability to think of atomic configurations in three dimensions and to work out endless structure factors, corresponding to all possible (and some impossible) arrangements of atoms.

Bragg himself was interested in all that went on and, on his regular visits to the laboratory, we would invariably receive the benefit of some very pertinent remarks before he continued on his rounds. He, too, as we all know, showed a remarkable intuition regarding crystalline structures. Once, when he had successfully worked out one or other of the silicate structures

which he and his co-workers were studying, someone asked him how he managed to hit on the correct structure from among so many equally plausible ones. He replied to the effect that he asked himself what the Almighty would do if he were putting together the atoms in the structure and that this turned out to be pretty accurate.

Life in the Physics Department at Manchester was close-knit and pleasant. The custom of afternoon tea was of course followed, with Bragg presiding, and no one would willingly miss it, whatever else he did, if he could possibly manage to be there. In many ways I was sorry to leave when W. A. Wood and I were offered jobs at the National Physical Laboratory in 1927, but as I had long been eager to work at the N.P.L. and as our task was, under Shearer, to set up a new X-ray analysis section, it looked too good to miss. And so it proved.

It was with some pleasure, then, that I heard of the appointment of Bragg as Director of the National Physical Laboratory in 1938. He brought with him Bradley, with whom I was very pleased to renew my friendship, and Lipson, whose friendship I have valued ever since. Bradley and Lipson joined the Metallurgy Department, where Preston was already working, while Shearer, Wood and I were in the Physics Department; but, needless to say the contact between the two groups was pretty close.

At that time I was working on the examination of the structure of dental enamel and dentine, by X-ray diffraction, micro-radiography and optical birefringence, and, once again, I was to experience the painstaking help which Bragg gave to his staff. He agreed to communicate a paper of mine to the Royal Society; and I have never forgotten his detailed criticism of the draft, which must have cost him a great amount of time and trouble, and certainly made for a much better paper.

But Bragg's time at the National Physical Laboratory was all too short; and in a year or so, he succeeded Rutherford at Cambridge, taking Bradley and Lipson with him. Then came the War which, for me, brought a complete break with my former work and thrust me into atomic energy as early as 1941, and then, *via* R.A.F. Bomber Command, back to atomic energy, at first in Canada and later at Harwell. Since then I have made contact with Sir Lawrence only at scientific meetings, on Committees, at the Royal Institution and so on. Of these I remember best the occasion of the meeting held at the Royal Institution in October 1952, to mark the fortieth anniversary of the discovery of X-ray diffraction. It was at this meeting, of which I was the organizing secretary, that von Laue made what was believed to be his first public speech in English. Many famous figures were present and Bragg was of great help in the arrangement of the historical exhibits, and in supplying me with material which I could use for the report I had been asked to write for *Nature*. On all these occasions I found in him the same keenness and enthusiasm and the same youthful approach that I remember from the first. Indeed it came as a great surprise to me to hear that his 80th birthday was imminent; and I am very grateful to be given this opportunity of paying my tribute to him.

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# Bragg, Protein Crystallography and the Cavendish Laboratory

BY M. F. PERUTZ

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X-ray analysis of crystalline proteins and viruses was begun at the Cavendish Laboratory by J. D. Bernal in the middle thirties, some years before Bragg arrived there. Bernal headed the Crystallographic Laboratory, a sub-department housed in a few ill-lit and dirty rooms on the ground floor of a stark, dilapidated grey brick building. These dingy quarters were turned into a fairy castle by Bernal's brilliance and his boundless optimism about the powers of the X-ray method. He would occasionally tell Lord Rutherford, the Cavendish Professor of Physics, of his first crystallographic excursions into the fields of biology, but no echoes of these encounters reached us students. We were but a side show among the glittering spectacle of atomic physics that unfolded itself in other parts of the Cavendish Laboratory.

Rutherford's premature death in the autumn of 1937 started a round of musical chairs in British Physics. W. L. Bragg moved from the National Physical Laboratory to Cambridge to succeed Rutherford. P. M. S. Blackett moved from Birkbeck College, London, to Manchester, and Bernal succeeded Blackett at Birkbeck College, taking all of biological crystallography with him, except myself.

Bragg's coming was heralded by the arrival of huge X-ray powder cameras built for the study of metals; they were accompanied by A. J. Bradley, the new head of the Crystallographic Laboratory, and by his assistant, H. Lipson, who had unravelled the structure of complex alloys at Manchester. I felt forlorn among my haemoglobin crystals, doubly so because my native Austria had been overrun by the Nazis, my parents had