Autobiography – Part 1

Alan Agar

His Memoirs from 1920 to 1972 -

Formative years and a grounding in electron microscopy

I was born in November 1920 in the small village of Hessle on the outskirts of Hull. My father worked for the Corporation, in an office concerned with car licensing. He had started work at the age of 13, in an effort to help support his mother. He served throughout the Great War, returning to the Corporation in 1919.

1. The Metrovick EM2, my first electron microscope.

2. At the Delft Conference in 1949. (Left to right: Ricky and Doris Revell, Margaret Agar, Mme. Castaing, Raimond Castaing).

After a few years in primary school, I joined the Boulevard Secondary School at the age of 8, and stayed with them until I was 18. I was very fortunate in being taught by a highly qualified staff, and with a headmaster who believed in a wide range of out-of-school activities. My parents were determined that I should go to University, from a relatively early age, though neither of them had had the opportunity. I qualified in maths, physics and chemistry after two years in the Sixth form, but stayed on a further year to try to earn enough scholarships to pay for College. I was fortunate to get an Open scholarship from Hull, and was offered Exhibitions from Queen Mary College, London and from Imperial College also. These Exhibitions were each worth £30 per year, while Imperial tuition cost £60 per year, and I clearly could not afford to take this up. The Hull scholarship of £60 would just about cover the living costs.

Just as I was about to start college at QMC in 1939, I heard that QMC was being evacuated to Cambridge, so I shared lectures from both QMC and Cambridge – including one memorable one from Aston on his mass spectrograph. I was obliged to take lectures from years 1 and 2 in the first year, since the wartime regulations permitted only two years at university. It was very fortunate that my physics master had covered most of the first year work already. In my second year, I was privileged to live in King's College, and was impressed by being able to sit in the choir stalls for the Advent Carol Service – an unforgettable experience. From time to time I had to patrol the roof of the Chapel to deal with any fire bombs that should fall during an air raid. I managed to subsist on my scholarships and a small amount of pocket money, but had to borrow £20 from my father to balance the books. I was awarded an upper second at the end of the two years which, under the circumstances, had to satisfy me.

In August 1941, I joined the RAF as an Acting Pilot Officer on probation – one couldn't go much lower! I spent six months at the Signals School in Cranwell, concentrating on communications rather than radar. After short postings in the UK, I was sent out to Algiers very early in January 1943. After a few months responsible for the servicing of aircraft radio equipment from two fighter squadrons on Maison Blanche airfield, Algiers, I was dispatched with a small team and a mobile radio station to Constantine, preparatory to the establishment of Air Force headquarters in that town and with the

task of establishing communication with Leighton Buzzard, in the UK. This achieved, I was soon moved on to the signals planning staff of NAAF. We moved to La Marsa, near Tunis, at the end of the North African campaign, and in spring 1944, to Caserta, where the unit became part of MAAF (Mediterranean Allied Air Forces). Our job was to organise signals requirements for the invasions of Pantelleria, Sicily, Salerno and Anzio. Some eighteen months later, I was moved to 214 Group Maintenance HQ in Naples, as second in command of the Signals section. I finally ended up as Squadron Leader in charge of the signals unit at 378 Maintenance Unit, in Castellamare di Stabia, in the Bay of Naples. I reached home nearly 3 and a half years after leaving England. I had to wait a further two months before release.

I was now at a critical point in my career. I did not have access to anyone who had knowledge of, or contacts in, either university or industry, and several QMC staff I knew had left. In the absence of such advice, I was feeling very lonely. So long away from study, I felt I must have forgotten most of the physics that I ever knew, and that I would find research work very difficult. I had already achieved the age of 26, without having started a civilian career. Looking back, I am sure that, like many returning servicemen, I could have settled back into research work satisfactorily, but I would then have been 29 before starting my career. At the time, this seemed preposterous! I therefore applied to a number of companies for a job. I found that many were reinstating staff who had been away in the services, and had nothing to offer. This applied to the Radio Department of Metropolitan-Vickers, but they thought that I might like to consider a graduate apprenticeship in their Education Department. With some hesitation, I accepted this, and went through periods of three months doing brazing on small transformers, turning on turret lathes, welding, engineering drawing, vacuum testing, physical chemistry and then electron diffraction in the research department. While at the time, progress appeared to be slow, I later very much valued the ability to read and produce engineering drawings, and the appreciation of engineering tolerances, and manufacturing techniques. In due course, it helped me to qualify as a chartered engineer as well as a chartered physicist.

On completion of my training, I was offered a post in the high-voltage laboratory of the research department, working on the development of specimen preparation techniques for electron microscopy, together with another junior physicist (Ricky Revell). At that time the relatively crude techniques for preparing specimens were a significant obstacle to increased sales of electron microscopes. We worked initially with the first series electron microscope made by M-V, the EM2, with a nominal resolution of 10 nm (Photo 1). Our supervisor was a high voltage specialist in heavy engineering, so we were left very much to our own devices. While this challenged our ingenuity, I think in retrospect it was inefficient since we made slower progress than might have been possible with a knowledgeable supervisor. Nevertheless we were able to have a number of papers published, and were sent to the first international conference on electron microscopy in Delft in 1949, where we each read a short joint paper. We met many of the then

3. Outside the EM building, HV Lab. Trafford Park. (Alan Agar, Ricky Revell, Joyce, our photographer, and Roger Booker).

4. Aldermaston Court, AEI Fundamental Research Lab.

leaders in the subject, and I was privileged to help Raimond Castaing translate his pioneering paper on microanalysis in the electron microscope into English, the official language of the Conference (Photo 2).

Progress in electron microscopy was limited, not only by crude specimen preparation, but also by severe limitations in the instrument itself. One major problem was drift of the specimen stage during the exposure of the plate (about 3 seconds). This could be caused by warming of the stage push rods, due to room temperature changes, or heating up of the windings of the objective lens, or wrongly balanced frictional forces, or due to thermal drift of the support film for the specimen – in those days, a plastic film which was subject to severe local heating by the electron beam. Under these circumstances, it is hardly surprising that many conference papers were criticised for wrong interpretation of linear structures – 'imaging artefacts' we called them. Since we had to demonstrate good quality pictures, we had to adopt very stringent standards, so that only a small proportion were deemed worth keeping – ruthless, but necessary to avoid misinterpretation of structure due to instrumental defects. This regime also meant that we had to be constantly aware of any fall-off in the instrument performance, and to be able to analyse the source of any trouble by observation of the image. We were joined for a time by a new trainee, Roger Booker (Photo 3).

In August 1947, I went on a week's walking holiday in North Wales, where I met Margaret Worthington, who was a school teacher in Blackpool. I instantly recognised her as my ideal girl, and knew I had to arrange another meeting soon. I proposed a theatre visit to Manchester, which she could not manage, but she invited me to Blackpool instead. So began a shuttle each weekend on the express bus – a two hour journey. She came to Manchester on alternate weekends. Before Christmas, we were engaged, and in June 1948, were married. We bought a house in Flixton, within cycle range of work in Trafford Park. Our first child, Janet, was born in 1950, and a second daughter Marjorie in 1953. Both Janet and I started to get bronchitis each winter (we had some truly awful sooty fogs in those days) so I decided we must leave Manchester. I secured a transfer to the fundamental research laboratories of AEI in Aldermaston Court in the autumn of 1954 (Photo 4), and started work in the Electron Physics team headed by Mike Haine, which had the major project of attempting to quantify all the factors affecting the attainment of very high resolution in an electron microscope. A prototype microscope utilising the

5. At Aeon Laboratories, describing the electron microscope during a Tomorrow's World programme.

results of these studies was built up and in early 1956, I was able to demonstrate a picture with a resolution of 0.5 nm. The working atmosphere was excellent, and we had a delightful social life, living in a small village. At work, I had learnt a lot about details of electron lens design, and also of alignment and deflexion systems.

Quite unexpectedly, I was approached in late 1956 to take the post of head of laboratory, at the newly formed Aeon Laboratories, at Englefield Green, Surrey. This was a consultant laboratory, looking for research work, using a range of good light microscopes and with the newly-available Siemens Elmiskop electron microscope, which was the first commercial instrument capable of regularly attaining a resolution of 1nm. We had a consultant panel of senior scientists to help with specialist problems. We received an extraordinary range of problems, some quite short-term, though we soon obtained research contracts both from the UK and the USA. The laboratory was also used as a demonstration base for potential customers for the microscope, and we, in addition, set up a service organisation to maintain the instruments in service in the UK. There was a great demand for these instruments, and I started a series of training courses for new users. This was quite essential because, although it was a powerful instrument, it was not easy to operate well without understanding clearly the electron optics, and being competent in making the necessary adjustments. I developed a set of notes to supplement the practical instruction, based on many of the techniques I had developed in my earlier work. This had to take account of the fact that many of those on the courses were biologists and unfamiliar with physics jargon. They nevertheless asked enough penetrating questions to cause me to rethink parts of my presentation. These notes later came in useful, when I expanded them in writing a book "The Operation of the Electron Microscope" (Agar, Alderson and Chescoe), Volume 2 in the series Practical Methods in Electron Microscopy. It had good reviews, and from 1974 for some years was the recognised text on the subject.

The laboratory flourished, and we soon had a staff of over 20. The problems we were presented with included rhesus monkeys infected with yellow fever (we found enlarged mitochondria), Mediterranean prawns, catalysts from the oil industry (we showed the tiny particles of the platinum amongst the ceramic matrix), high performance metal alloys with very fine alloying particles (needed to improve the creep properties at high temperatures – if I remember correctly, these samples came from Rolls-Royce), some extremely radiation-sensitive plastic for which I had to devise a way of obtaining a picture before all the structure was destroyed by the electron beam, and the more mundane, some beer with an over-foaming problem, and chocolate that had developed an unwanted bloom!

One of the excitements we had, was the broadcast of Tomorrows World, live from our laboratory. I had the job of explaining the microscope, and in a fairly small room, the TV cameraman backed into a corner, and accidentally switched off the microscope at the mains. It had a time delay on the switch-on, and the beam reappeared just seconds before we were on the air – not calculated to fill the operator with confidence (Photo 5).

The laboratory was owned by an idiosyncratic individual who apparently did not entirely trust me. He took a rather dim view of the correspondence I received, first as Secretary and later, Chairman of the Electron Microscopy Group of the Institute of Physics. He said there were more letters about Institute business than for the laboratory. He apparently failed to appreciate that his business was far better known as a result of these activities. We maintained a wary relationship, but in the end, after five years, he suddenly accused me of incompetence, for no particular reason that I could discover. The sheer effrontery of this led to my immediate resignation. I was furious at the injustice, since much of the success of the laboratory was due to my own efforts, and the very good staff we had. (Within two years of my departure, the company went into receivership due to an ill-advised venture in an associated company, due entirely to the said owner). I still gained a great deal from this period, because I had friendly relations with large numbers of our customers, many in senior positions, and these contacts were to be very valuable at a later date when I started my own business.

After looking around at different possible openings, I accepted a post with AEI, not in the research department, but in the scientific apparatus department. Its main products were mass spectrometers, electron microscopes, and vacuum pumps. I was initially engaged as a consultant with a brief to set up a consultant laboratory after the model of Aeon Laboratories. To avoid a move to Manchester, and because there was to be a possible move of the electron microscope team to the South, I had temporary accommodation in the research laboratory in Aldermaston. In a little over a year, the whole electron microscope business was moved to a new factory in Harlow, Essex, since there was an urgent need to increase the production levels – there had been no available space in Manchester.

This move necessitated us moving house to Bishop's Stortford; leaving behind a house we had built in Reading to our specification, and which we were very sad to leave. While in Reading, we had the joy of a new daughter, Helen, some eight years behind Marjorie. Helen had the benefit of lots of attention from her two big sisters.

I joined the Manchester contingent as they arrived in Harlow in 1964, and was promoted to Engineer-in-Charge. I had a number of ideas culled from operating the Siemens microscope which I hoped to incorporate in future instruments. There were several first class engineers in the team from Manchester, but they were woefully inadequate in number to do sufficient detailed engineering, to ensure the required level of serviceability. They had, at final prototype stage, a new and excellent microscope which was desperately needed for commercial reasons but which proved to have an annoying fault which appeared once in service. There were motor-driven vacuum seals which swung into the beam path to seal off the specimen region, to ensure rapid change of specimens with a minimum pump-out time. It turned out that the motors were not powerful enough to ensure a good seal reliably, and furthermore, even though the retracted seals were well clear of the beam, there were enough scattered electron to damage the viton seals, so that they soon became brittle. We finally had to redesign the whole system.

The new factory needed a good deal of engineering help to solve problems in manufacturing an instrument which involved so many disciplines – very stable electronic supplies for the lens currents, highly stable high voltage supplies (up to 100kV), extremely tight tolerances on lens bores, and for the specimen stage, a need for clean vacuum assembly, critical handling of lens magnetic circuits, and a need for great stiffness in the assembled column. It is perhaps, a misfortune of an electron microscope that the operator can detect small deviations in performance that are difficult to measure by conventional measurements of individual components. The final test procedure is therefore, a most important operation, and was, for a long time, supervised by a senior engineer until the testers could be trained to an adequate level of skill.

It appeared to me that we could not catch up or compete in the world market unless we could make and sell more microscopes, and establish a much stronger engineering team. I had every confidence

in our technical ability. We had consistently introduced new thinking into our instruments in the past, and they were technically advanced. I expected that in this expansion stage there would have to be a significant investment into the project. However, after about three years, after AEI had been taken over by GEC, pressure mounted for us to show an immediate profit from the business. This was not helped by a very slow manual costing system, based in Manchester, so that we had very little idea of current costs and none at all of many overheads, such as the charge for the overseas division, which only appeared at the end of the financial year.

The expansion of production capacity was quite successful and the inherited backlog of 18 months of orders was transformed into delivery from stock after about three years. Unfortunately, we were much less successful in expanding the sales, especially in exports, where we had hoped to make significant gains. The very long delivery delays had seemed to be the main reason for restricted sales, but the new quick deliveries did not transform sales levels as much as we had hoped. The engineering was reorganised to allow for better mechanical design and a more modular construction to permit changes in individual components without major system redesign. We also, at last, had the effort needed to design accessories which extended the operational scope of the instruments. We were too slow in starting the engineering of the next generation of instruments, being delayed by the effort needed in the factory, and in clearing some of the inherited backlog of work.

After two years, I was appointed as product manager, electron microscopes. This seemed a logical progression, in that the sales were dependent quite often, on the technical features which could solve a particular problem. I took over the sales staff dealing with promotion and direct sales in the UK. Most overseas sales were dependent on the old Metrovick organisation, where they established a sales office in most countries, which handled sales of the whole range of Metrovick products. Since the principal business of the company was in heavy engineering, the instrumentation business was not handled with either enthusiasm or any technical understanding in many territories. Fortunately, we had a direct selling agent in the USA, and there were some knowledgeable enthusiasts in a few countries such as Australia, Canada and India. Overall, however, this was not an effective organisation for expanding our exports. We did our best to support those offices showing the most lively interest, with technical visits and help. We also attended any local conferences on electron microscopy so that we could talk directly to potential customers. After attending a Trade Fair in Moscow, I was invited to visit the Russian factory making electron microscopes, in Sumy, Ukraine (Photo 6).

Two technical developments affected our engineering programme. The Tube Investments Laboratories developed an ingenious instrument which combined an electron microscope with analytical X-ray facilities ("EMMA"). They got some valuable results from it and offered it to us to exploit. It was the first instrument with such facilities and looked to be a useful supplement to our range. Their machine was well engineered, and we thought it would not be a major job to adapt. However, to avoid manufacture of many different components, we decided to graft it on to one of our existing microscopes. This turned out to be much more complex than expected, and so it was delayed in appearance, as well as diverting a lot of engineering effort. To make matters worse, the performance of solid state X-ray detectors had improved dramatically in the meantime, enough to make their attachment to a microscope column at least feasible, though with a poorer performance. In retrospect, I think we should not have undertaken this project, though we were conscious that a rejection would have aroused much criticism for not taking up a good idea like this.

In the mid-60s, there was a surge of interest in very high voltage electron microscopes (500-1000kV). A survey around the universities and AERE Harwell showed an initial demand for five instruments. A laboratory instrument had been built in Cambridge University, but it was apparent that it would need major modification to meet the new requirements. The Government agreed to fund a batch of five of these instruments, to be allocated to Harwell, NPL, and three universities. We accordingly set up a joint AEI – customers committee, at which the main features of the specification were discussed and agreed. We believed this to be a very rare occurrence, far removed from the reputation of a company failing to consult its prospective customers. In fairness to AEI, our engineers had in

6. As Product Manager, Electron Microscopes, visiting the Russian Electron Microscope factory in Sumy, Ukraine in 1969.

previous years gone to a number of our customers to determine the specification they required for a biological microscope, for instance. It was just unlucky that the advice given proved not typical of what a majority of people turned out to want! The result of all the collaboration was an excellent design, superior to that offered by Japanese companies. However it did prove more costly than the initial estimates. These one-million volt microscopes were duly put into service, and several were worked around the clock in order to meet the heavy demands on them. The AERE instrument was immediately used to examine the effects of radiation on various materials. The results were surprising – the rate of radiation damage in the microscope far exceeded anything available in an atomic pile, so the instrument was used for much of the time in this mode – as a high intensity radiation source, and rapidly paid for itself. We were able to use a new team of engineers for this project, though it also occupied a good deal of my time and that of our senior engineer. It therefore diverted some attention from our main programme, which was at a critical stage.

I found the heavy emphasis on profit very worrying at a time when our engineering investment had not yet come to full fruition. We were still in the later stages of engineering new models that were badly needed to boost our sales, which were becoming more difficult in a market which since 1966 had shown a contraction in sales of transmission electron microscopes (TEM). This was due to the launch in 1965 of the first commercial scanning electron microscope (SEM). Although the resolution of the scanning instruments was not comparable with that of the TEM, the new imaging possibilities of the SEM led to some of the funding being diverted in that direction. At about this time, discussions with Cambridge Instruments (making the SEM) with a view of a possible merger, went on for some time before breaking down. This proved to be a major blow to the ambitions of AEI to be a major EM supplier; a merger would have led to major cost savings both in engineering and sales.

7. Presentation of Honorary Fellowship by Audrey Glauert, President of the RMS.

By mid 1969 I was very stressed in the very difficult working conditions, and looking back I was less effective than I should have been and mistakes were occurring. I had, from time to time, made proposals to reorganise our foreign representation, since we were not up to budget in increasing those sales. Initially I did not get much response to this, but following my emphasis the Managing Director asked me to go to the USA for a year as technical adviser, to boost the field sales effort there – it was, after all, the biggest potential market, and I had to agree that I could indeed have a bigger effect than anyone else in the organisation. After deep discussions at home, we decided that it would be a marvellous experience for the two younger children (Janet was by then in Southampton University) and not at all bad for us. Of course I did realise that I was taking a risk with my future career. In September 1969 we flew off in a VC10, and some friends we knew in Stamford, Connecticut, found us a house to rent.

Our agents in the USA were Picker X-Ray Corporation, based in White Plains, New York. They used a field sales force whose function was to find as many prospects for electron microscopes in their area as possible. When they knew that a prospect was actually going to get funds for the purchase, they would call me up to visit the customer to use all the technical arguments to show how our microscope would meet their needs. For many years I had been using microscopes for different problems, so I could keep the argument strictly on a scientific basis by finding out just what facilities would be most useful. The field sales force soon discovered that this was an effective approach and before long I was flying all over the US in response to calls for help. I also lectured extensively on our new high voltage microscope, which was the subject of great interest at the time. It is worth noting that while in England, I had been very critical of the high discounts needed by Picker on microscopes sold to them (40%). This was far more than the profit we could retain. Once in the States, I realised that in such a huge country there was no way in which we could use product specialists to do all the work. There were large numbers of laboratories trying to get funds and we needed the local sales representatives to keep track of those people who were worth spending time on. Picker had some dozen offices spread around the country, so some covered a very large area indeed. We therefore had some very long motor journeys to visit prospects. I would quite often take a morning flight to Chicago, being met by our local representative, visit two or three prospects, and be put on the evening plane to New York – rather like going to Rome for the day – something we would never then have dreamed of doing in Europe. This showed me that the high sales margins were needed if we were to make a serious impact on the numbers of instruments sold.

It was interesting to be out at the sharp end of things – I had to do a lot of chasing the company at home for delivery of vital items and for information. It was rather sobering to see our home operation from afar – we were not as good as it had seemed while working there. On the other hand, I could not complain personally, as I still had a lot of clout and got good service.

At the end of a year the decision was made to set up our own company to deal in the USA, and I was urged to stay on in the USA and offered a lucrative permanent post with them. I was certainly tempted, particularly because there seemed to be a good chance that we could soon secure our first order for a high voltage electron microscope. However I was determined that we should be back in England in time for Helen to start in an English grammar school. I therefore agreed to stay on for just one more year before returning to England. At that time, our high voltage microscope sold for about $500,000, while a Japanese competitor was offering an instrument for $350,000. It was therefore, quite an uphill task to persuade anyone to buy our microscope, when there were Japanese microscopes already working in the US. However, our very good specification swung the deal, and by agreeing to incorporate a special facility for our first customer in Madison, Wisconsin, we got the order. Before the end of that year, we also secured an order for the New York State Laboratories in Albany, and a further order for Chicago was imminent.

During a short stay in England in the summer of 1970, I was presented by Audrey Glauert with the Honorary Fellowship of the Royal Microscopical Society, which I had served as a member of Council and a Vice President (Photo 7).

At the end of my time in the USA, I found I had driven some 50,000 miles by road, and clocked up 250,000 air miles. As a family, we had twice been round the Rockies and to Yosemite and Yellowstone, and toured the northeast up to Vermont and Montreal, and down to Virginia. This was achieved at the expense of our savings, but it was money well spent.

I felt well satisfied with my efforts and received a glowing letter of thanks from the Managing Director of our US Company for all I had contributed.

On my return to England however, I found that my old post was no longer available and I was given a half-job with limited responsibilities. The new general manager in the UK was very abrasive and informed me that I had not been intended to return. He even criticised me for the cost of the expense I had incurred in getting our first HVEM order. Six months later the very nasty atmosphere resulted in me having a slight heart attack, and spending a few weeks in hospital. This provided a very useful quiet time for thinking. It was obvious that there would be a severe retrenchment in the business and I certainly no longer wished to stay in it. I hated the new precedence of money and accounts over service to the customer. I had no confidence in the new engineering programme (for which I was not consulted), which was aiming for another new type of microscope, a scanning transmission electron microscope (STEM), instead of going for the less glamorous routine models, which were far less risky. This new departure eventually sealed the fate of the AEI microscope business.

I decided that I would never again work for a big company and started by enquiring of some of my friends in universities if there was any chance of a post there. However, they advised me that there was little chance of this in the difficult conditions that were developing. This left the option of running my own business. The first idea was to retire to the countryside and run a small shop/post office, but a study of the economics of this rapidly convinced me that this was not a good idea. I was not discouraged about starting a small business though, because on looking around, I could see many such businesses and thought "If a clot like that can run a business then so can I!"

To be continued...

Read Part 2 in the December 2009 issue of infocus.