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The Marconi Research Centre - Great Baddow, Essex

The seed from which the Marconi Research Laboratories (now the Marconi Research Centre within the GEC Research Laboratories) were to grow came from the grounds of the Villa Griffone, near Bologna, where the young Marconi carried out his first experiments on the generation and transmission of wireless waves. Their existence had been predicted by Maxwell and demonstrated by pioneers such as Hertz, Lodge and Branly, but their potential for use first in communication and later in radio and television broadcasting was only established by many years of disciplined research by Marconi and others of his generation.

Marconi formed his company in London in 1897 with the name the Wireless Telegraph and Signal Company, changed some three years later to Marconi's Wireless Telegraph Company. For some years the research work was carried out by Marconi himself with a number of colleagues amongst whom were C.S. Franklin, Captain H.J. Round and Dr J.A. Fleming (later Sir Ambrose Fleming), who was Scientific Advisor to the Company from 1900 until his retirement in 1931.

In 1912 a Research Department was formally constituted under Franklin in a small building near to the Company's Hall Street works in Chelmsford, but with the outbreak of the First World War it came under the direction of the Admiralty, to whom all the Company's activities were largely devoted until 1919. In 1921 the Research Department was reconstituted, this time under the direction of Captain Round, but the decision was taken to form a separate Research Department under Franklin, perhaps an indication that great minds do not always think alike!

In 1916 Marconi had carried out some early experiments on the generation and propagation of short waves and the topic was regarded as of such importance that Franklin and his small team were asked to devote most of their attention to it. In 1919 T.L. Eckersley, who was to become one of the world's foremost experts in the theory of propagation of electromagnetic waves joined the Company and the results obtained by his researchers encouraged Marconi to believe that a worldwide communication system based on the use of short waves was practicable. In 1924 the company received a contract from the Post Office and successfully put such a system (the Empire system) into operation.

In 1930 a Television Research group was formed and in 1931 research was formally separated from development, with the appointment of H.M. Dowsett as Research Manager. Dowsett was succeeded by J.G. Robb in 1935 and the following year the decision was taken to draw together the various research teams, located in and around Chelmsford, into a single laboratory and a site was purchased at Great Baddow, sufficiently far from possible sources of electrical interference to permit research work to be carried out on the detection and amplification of very small signals.

Building work began in 1936 and by 1939 the laboratories were in operation under Robb's direction, although some of the groups has been brought to the site in temporary accommodation earlier. (The hut occupied by Eckersley and his propagation team in 1938 is still in use by the current generation of propagation specialists in 1985!)

The completion of the buildings provided the opportunity for drawing together various research activities on propagation, low-noise receivers, radio direction finding, television and specialist component studies, the latter including quartz crystal development and gas discharge devices. With the sole exception of television all these were of potential importance in wartime and it was not surprising therefore that very soon after the commencement of hostilities in 1939 the laboratories disappeared under camouflage netting and come again under the control of the fighting services.

In April 1940 the Air Ministry took over part of the unit, including T.L. Eckersley and his team, which had been joined in the 1930's by G. Millington, also to become an internationally respected authority on electro-magnetic wave propagation. In 1941 the rest of the laboratories came under the control of the Admiralty and for the remainder of the war cooperated with the Admiralty Signals Establishment in fulfilling the urgent needs of the Services. (The Chief Scientist of ASE during this period was G.M. Wright, who had occupied one of the senior posts in the Marconi Research Department in the 1930's and who returned to the Company as Engineer in Chief in 1946.)

In 1941 the Interservices Ionospheric Bureau was formed, under the auspices of the Admiralty and the RAF, to take advantage of the knowledge and expertise of the propagation team. It was reinforced by officers and other ranks from the RAF Royal Navy and US Army Signal Corps. Amongst the last were John Kojan who joined the Marconi Company's permanent staff after the war and Dana Bailey, who had come from the US Bureau of Standards and who returned there to pioneer the application of Ionospheric Scatter in the 1950's. The team devised techniques of ionospheric sounding and developed measuring equipment the results from which were used to predict the performance of h.f. radio channels. Typical of the equipment built and put into service was a pulse transmitter feeding a wide-band rhombic aerial for vertical incidence ionospheric sounding. The equipment was installed at Stock (about six miles from the laboratories) on a site with the inappropriate name of Smallgains Lane! It was controlled by telephone line from the laboratories and the delayed echoes received from the ionosphere were monitored round the clock by the RAF operators. Data assembled from measurement of this sort was circulated to all three services to guide system operators in selection of optimum frequencies for h.f. communication. (Similar information is still compiled by the Propagation Group in the

Marconi Research Centre and circulated to a wide range of h.f. users via H.M. Stationery Office Publications.)

While the measurement and prediction of h.f. radio performance was the predominant activity of the propagation team in the war years, attention was also devoted to tropospheric influences on direction finding and radar systems and to many other topics referred to the specialists by service users. Dr R.V. Jones in his book 'Most Secret War' describes how his attention was drawn to a report by Eckersley which showed that it was possible for German bombers flying over the UK to receive guidance signals from a transmitter on a sufficiently high site in Germany. It appears that Eckersley changed his mind at a conference at the Air Ministry but his report was nevertheless the spur which led Jones to initiate the measurements which demonstrated that the bombers were indeed being directed by a beam system originating in Germany and resulted in the introduction of effective countermeasures. Jones described Eckersley as "The country's leading expert in radio propagation" and it is apparent from references in the book that his work and that of his team at Baddow were vital to the war effort.

Another activity of considerable wartime interest and well established in the laboratories from their inception was radio direction finding, work on which was being prosecuted in several different groups. At the outset considerable assistance in the design of the receivers used in d.f. was given by Dr E.E. Zepler who had been head of receiver development in Telefunken, Berlin and with his colleague Dr Bohm, Head of Research, had been obliged to leave Germany in the mid-1930's. However Zepler as a German subject, was interned in 1940 and after gaining his freedom about a year later became a lecturer at Cambridge and subsequently the first Professor of Electronics at Southampton. Other engineers continued the work on direction finding notably in teams led by S.B. Smith and by R.J. Kemp, whose activities had been switched from television in the interest of the war effort. Work on receivers was led by R.B. Armstrong, whose team included Dr G.L Grisdale and Mervyn Morgan both of whom were to reach very senior posts in the Marconi Company after the war. Apart from its use in propagation research direction finding was used in aircraft, ships and land-mobile equipment, in the monitoring of transmissions from the enemy and even in spy-catching.

The Company had not been closely involved with the development of radar prior to the war although Marconi in a speech to the American Institute of Engineers in 1922 commented that he had observed reflections of electromagnetic waves by metallic objects miles away and suggested that this might be used for detection and determination of bearing of ships. When, following the work of Watson-Watt and others, the decision was taken in 1935 to install CH radar stations around the UK the responsibility for supply and installation of the transmitter 'curtain' arrays was given to the Company, and by 1942 parts were being shipped out of the Chelmsford factory for use in a naval centimetric radar. In 1943 a contract was awarded to the Company for development of the 960, a naval radar operating at a frequency of about 90 MHz. The transmitter was developed by the Transmitter Development Group in the main factory and the aerial, receiver and display units in the Research Laboratories. C.D. Colchester was principally responsible for the aerial and C.S. Cockerell (later Sir Christopher Cockerell, inventor of the hovercraft) for the display. First trials of the equipment were made in October 1944 and the first operational set was installed in HMS King George V in August 1945. Notwithstanding the relatively early date of design and the short development cycle the equipment embodied both sophisticated anti-jamming techniques and a built-in noise jammer.

One activity carried out in the laboratories during wartime was in a very different field from that normally associated with Marconi. The Company had, during the period of depression in the early 1930's, begun to look for new outlets and had undertaken studies on the use of electro-magnetic energy in medical diagnostics and therapy. Under the leadership of A.W. Lay a small team had developed a spark generator operating at about 1 MHz for electro surgery and diathermy. Work continued during the war and equipment was supplied to the Army for surgical use in the field. The instrument known as the Marconi Ekco Therator was used both for cutting tissue, by applying intense but controlled current in the appropriate area, and for control of blood flow, by applying local heat to a blood vessel and thereby encouraging coagulation. Since operations were virtually bloodless and instantly cauterized the instrument was popular with army surgeons and the commander of the New Zealand forces wrote to Lay to tell him that his machines had saved the lives of over 1,000 New Zealand troops.

The machine, as a spark generator, inevitably radiated energy over a wide part of the e.m. spectrum and was used in one variant as a jammer against the German beam system referred to previously.

During the war period much research was devoted to components partly because many devices were special to the equipment and partly because new component developments offered the prospect of equipment superiority relative to that of the enemy. In the second category the most important example was almost certainly the emergence of the cavity magnetron from the work of Randall and Boot at Birmingham University in 1939. The Marconi Company had in 1919 pooled its resources with those of GEC to form the Marconi-Osram Valve Company (still part of the GEC Company as M-O Valve Company) but maintained a samll vacuum physics research team in the Baddow Laboratories, led by Dr Brett. At the outset of the war this was making small quantities of the Stabilovolt, a gas discharge voltage stabiliser with taps at 70 volt intervals up to 280 volts based on a German design. The requirement for stabilised power supplies in most military equipment led to a vastly increased load, compounded by an involvement in magnetron development, on the Baddow team. Brett, who had been seconded temporarily to the Admiralty for similar work with Dr Sutton returned to Baddow and was joined by A.J. Young, who had worked with Aisenstein in running valve manufacturing facilities for the Marconi Company in Russia and Poland. Young led the work on magnetrons which closely paralled that at GEC's Hirst Research Centre and the M-O Valve factory and produced devices for centimetric transmitters being delivered to the Admiralty from the Chelmsford factory. By May 1942 demand had grown to a level well beyond the resources of the laboratories and a production unit was set up at Waterhouse Lane, Chelmsford (at peak production in 1945 nearly 2,500 magnetrons per month were leaving the factory). After the English Electric Valve Company take-over of the Marconi Company in 1946 this unit became the English Electric Valve Company and still includes magnetrons as one of its major product lines.

Amongst the passive components used during the war and subsequently was the quartz crystal on which most communication and navigation systems depended. A team led by Norman Lea was carrying out research on methods of frequency stabilisation, including methods of reducing the effects of long term drift in crystals which was a troublesome problem in equipments of that generation. In parallel T.D. Parkin and colleagues were engaged in the growth of crystal quartz and the cutting of crystals for use in the stable sources. The majority of the sources were embodied in equipment being manufactured in the Chelmsford factory and the demand grew to such an extent that production units specific to the purpose had to be set up. (Over 9000 were made in 1943.)

Publication of many of the activities carried out during the war years has never been made because of their relevance to national security but they can best be summarised as a sequence of reactions to national needs as they were foreseen at the time and as they developed as the war proceeded.

(This policy was not confined to the technical work. The Laboratories had its own Home Guard platoon, led by the unit's cashier, Norman Knight, and including men from all facets of its activities. They were as ready to respond to physical challenge as they did to technical problems had the occasion demanded it!)

Research had to be devoted to short-term aims and the results embodied in practical equipment in the shortest possible time. Longer term projects such as television had to be put on one side and individuals had to adapt themselves to new roles and new challenges. However, many of the techniques and devices which emerged from the wartime work were to find application in peacetime roles later and those members of the research teams who had not moved permamently into development, manufacturing or commercial activities had developed the expertise and motivation to take on the new tasks which the end of hostilities presented to them.

After the war ended the Service Units withdrew from the site, staff who had been seconded to work elsewhere e.g. at the Admiralty Signals Establishment or at TRE Malvern returned, and the Laboratories turned their attention to peactime needs. The nature of the research did not however undergo a fundamental change. For example there was still a need for precise control of frequency of communication channels and work to overcome the long term drift of quartz crystals was continued. The problem was eventually overcome by packing the crystals in glass sealed units and later in T05 cases, similar to those used for transistors. The frequency range over which crystals could be supplied was also extended from 1 kHz to 100 MHz, using flexural modes at the lower end and overtones at the upper and frequency stability was improved by enclosing the crystals in ovens at precisely controlled temperatures - determined by change of state of a material such as paraffin wax. In Lea's frequency control team these developments were incorporated into frequency standards with drifts as low as a few parts in 10^{10} per month which could not be surpassed until the arrival of atomic standards. An example of an equipment resulting from this work was the TME2 Frequency Measuring Equipment used by the BBC at its Tatsfield monitoring station and by broadcasting administrations throughout the world.

The initiative on television, research and development had been lost to the United States during the war years but work was restarted in 1946 in a team strengthened by the recruitment as Chief Television Engineer of L.H. Bedford, who had been one of the leaders in radar development at Cossor's. An agreement with RCA enabled the team to obtain up to date information from which to advance their own work and by 1949 Bedford was able to demonstrate to an audience at the Royal Society of Arts, pictures from an image orthicon camera which lost very little in either contrast or definition when the source of illumination was changed from a spotlight to a single candle. In the same year the Varsity Boat Race was for the first time televised from start to finish using a similar camera and the research team was able to turn its thoughts to the problems involved in system improvements including the introduction of colour to the pictures.

The Marconi Company had not been involved in the manufacture of domestic radio receivers since 1929 when it sold its interests, including the use of the name "Marconiphone" and the copyright signature "G. Marconi", to the Gramophone Company. However in the late 1940's the Baddow Laboratories were given the task of designing a television receiver (the 1550) which was put into production in an English Electric Factory at Liverpool. This particular activity was not a success, possibly because the design team was not attuned to the requirements in terms of high reliability at low cost of the domestic market, and although work aimed at design improvement was continued into the early 1950's the decision was taken to discontinue manufacture and the team transferred to other work.

In the meantime the studio research team was studying the problems involved in introducing higher resolution black and white systems (625 lines instead of 405) and colour. Under the direction of L.C. Jesty they made an experimental 2-tube colour camera which was used for demonstration purposes well before the decision was taken to standardise on the PAL system in the U.K. and assembled the necessary background technology to enable a development activity to be launched immediately the decision on the preferred system was known. In 1956 it was decided that system principles were sufficiently well established for the television activity to move out of the research domain and the team transferred to development activities at Chelmsford, dividing their interests between two divisions - Broadcasting and Closed Circuit Television.

When the Laboratories were first formed a small team led by N.M. Rust was given the specific responsibility for exploring new ideas which could be used as the basis of patents, the Marconi Company from its inception having had a strong tradition for initiation and exploitation of patents. This team like others was engaged on activities specific to the war effort but as it ended began to study again how some of the ideas formulated could be used in peacetime. In the period 1946-47 J.F. Ramsay published in the Marconi Review a series of articles on Fourier Transforms in Aerial Theory which was widely used by antenna engineers throughout the world for many years, until the advent of digital computers made it possible to improve on the analytical design techniques which he described.

Within Rust's team work also began on the possible uses of the upper end of the microwave frequency spectrum, one of the participants being P.S. Brandon - a future Chief of Research for the Marconi Company and later Professor of Electrical Engineering at Cambridge University. A magnetron to operate at about 40 GHz had been designed in the Services Electronics Research Laboratory at Baldock and was being further developed at Elliott

Bros Ltd Borehamwood. Other system components were designed at Baddow and used as a basis for system experiments. Very few of the components for the frequency band were readily available at this time and the Laboratories had to design and manufacture their own. In doing so they developed a number of relatively new techniques such as electroforming, and precision casting and machining and although the 40 GHz work was temporarily suspended in the early 1950's these were applied successfully in other frequency bands and were resuscitated in the 1960's when work began on low loss waveguide transmission for potential use in trunk communications. At 40 GHz many of the techniques were quasi-optical and amongst the antenna components studied were lenses in an "egg-box" construction i.e. a 3-dimensional array of rectangular waveguides bonded together and dimensioned so that the phase change of an electro-magnetic wave passing through the structure varied over the cross-section in a way precisely analogous to that in a dielectric lens.

Brandon and others were at this time carrying out research on FM radar and designed an S-Band system which was used to carry out experiments on a site at Benacre, near to Lowestoft. This excited interest from the Admiralty (for submarine Schnorkel detection) the army (for sentry use) and some non-military users, including the Marconi International Marine Company but did not develop into a practical system, primarily because the technology was too far ahead of the market need.

Other work such as that on direction finding, precise frequency control and measurement and electromagnetic wave propagation continued throughout the 1940's but the Marconi Company, which had been owned by Cable and Wireless (Holdings) since 1929, became part of the English Electric Company in 1946 and this was to introduce a new personality of considerable influence, Dr. Eric Eastwood, and a new area of activity to the Research

Laboratories. F.N. Sutherland an English Electric engineer of considerable experience had become General Manager of Marconi at the beginning of 1948 and at about the same time R.J. Kemp succeeded Robb as Chief of Research. It was decided to transfer the task of up-dating a little-used wartime radar the Type 11, operating in the 600 MHz frequency band, from the Nelson Research Laboratories at Stafford to Great Baddow. (The up-dating involved conversion of the relatively crude coho-stalo system of moving target indication to a fully coherent system). Although the two events were not directly connected Dr. Eastwood, who had worked on radar in No 60 Group, RAF throughout the war, for much of it with the rank of Squadron Leader, also transferred from Stafford to Baddow at about the same time in order to take up an appointment as Deputy Chief of Research. Thereafter, Kemp tended to concentrate on the longer established activities of the Laboratories and Eastwood on the development of new ones, with a particular emphasis on peacetime applications of radar. Work had already begun by 1946 on the development of marine radar for use by merchant shipping. The prototype of an X-Band radar, subsequently to be marketed by Marconi International Marine Co Ltd with the name Radiolocator I, was built in the Research Laboratories by a team which included R.P. Shipway, recently returned from wartime service at TRE, and B.J. Witt. It was installed on the Duke of Lancaster, operating between Heysham and Belfast, after which responsibility for further development and manufacture passed to the main factory in Chelmsford.

Eastwood's first major task, in which he was assisted by C.D. Colchester and Shipway amongst others, was a major study of the UK ground radar defence system carried out on behalf of the RAF and culminating in a set of recommendations for up-dating (known was Project Rotor). Subsequently this was extended to cover overeseas radars also (Project VAST). The Air Ministry accepted most of the recommendations in the report in 1949 and much of the redesign and manufacturing was entrusted to a newly formed Division of Marconi's (then called Services Equipment Division and later Radar Division) leaving Eastwood and his colleagues to turn to other topics.

One of these was the study of the use of a previously neglected frequency band for ground radar. The early CH ground radars in the UK had operated in the HF band (about 25 MHz) and the later generation following the development of the cavity magnetron in the centimetric bands (about 3 GHz). An intermediate band, around 200 MHz had been used for GCI (Ground Controlled Interception). The new work was centred on 1.3 GHz and it was hoped to get some of the advantages of all the other three, e.g. relative freedom from the dense clutter experienced on centimetric radars when operating in rain, considerably better detection of low flying targets than was achievable in the HF band and height finding with a single radar antenna, as in the GCI's but without the necessity of using the very flat sites which had characterised them. Again there was little test equipment and few components available for this frequency band and much of the early period was devoted to developing both. The research was successful in that it demonstrated the feasibility of developing a long range radar with excellent anti-clutter characteristics in this waveband but the objective of carrying out bearing measurement and height finding from one antenna system was not achieved. The idea which was attributed to C.D. Colchester who also led the team was to use three waveguide arrays, each with a radiating flare, mounted above one another. Signals from the upper and lower were combined and compared with that from the centre. Since the combined beam was only half the width of the centre one the ratio of signals varied with angle of elevation but, as both originated from antennas at the same mean height it was hoped that the effect of earth reflection would be the same for both and that the derived elevation angle would not appear to vary due to site effects as the antenna rotated. The experimental work showed that the variation was in fact sufficient to make the derived angle of elevation, and therefore target height, much less accurate than could be obtained from a dedicated narrow beam heightfinder and the idea was not pursued. Surveillance radars for this band were however developed and marketed by the Company for both military surveillance and civil air traffic control following this work.

An interesting aspect of this work was that of clutter suppression. The Type 11 referred to earlier had employed a technique of moving target indication (MTI) which involved comparison of the phase of signals received from successive radar pulses, with phase in each case being referred to that of the transmitted pulse by use of either coho-stalo or a coherent drive system. The comparison was made by delaying the earlier received pulse in a water delay line - a temperature controlled vertically mounted column of water with input and output transducers at the upper end to convert the radio frequency signal to acoustic and vice versa. The pulse recurrence frequency demanded by the system was such that the path through the water, from surface to base and back again had to be about 3 metres (i.e., the tube abouth 1½ metres high) which made the system cumbersome and impractical for anything other than a static installation. The MTI team led by W.S. Martley devised an alternative system whereby the delay medium was mercury, in a shallow flat cell, with the acoustic wave transversing it horizontally by a tortuous multi-reflection path. The cell while still very heavy required considerably less space but became obsolete very rapidly when it was appreciated that the same effect could be achieved by passing the acoustic wave through an irregularly shaped multi-facetted slab of quartz, designed so that the signal crossed the slab many times from its launch by the input transducer to its emergence at the output. Quartz being a material low with low expansion coefficient the delay cell was not only much lighter and smaller than the mercury equivalence but it also needed no temperature control and was not subject to spillage. In addition to their work on cell materials Mortley and his team developed the amplifiers necessary to drive the input transducers and to amplify the output signals and this work led subsequently to the use of quartz and other materials in pulse compression for radar.

Although much of the work in the radar field was stimulated by the requirements of UK and Overseas Defence Authorities attention was also being given to potential civil uses of radar. In 1952 the Marconi Radar Division was awarded a contract for an air surveillance radar to be used for aircraft control at Jersey airport. It was intended that this should be based on the marine Radiolocator but the requirements for appropriate cover in the vertical plane demanded a new antenna design with switchable beams, one having a $Cosec^2$ shape for longer range targets, and the other having a square high cover pattern for use when targets were close in. Circular polarisers were fitted to the antenna to reduce the effect of rain attenuation, which could be relatively severe because of the high operating frequency (10 GHz). The transmitter tube for this radar was the English Electric 4J50, delivering a peak power of 200 kW (0.5 μsec pulse, 1,000 pulses/second) which was high for that time. This prototype, designed almost entirely in and installed by the Research Laboratories and employing a number of new techniques was in operational use in Jersey until 1969 when it was replaced by a new design operating at approximately 600 GHz.

By the mid 1950's a total capability for pulsed radar research was established in the laboratories, G.N. Coop who had worked on television transmitters and on the 1.3 GHz transmitter within the Chelmsford works, having transferred to the laboratories to lead a high power team; O.E. Keall and others working on receivers and R.F. Shipway and colleagues on display and data handling systems, all in conjunction with the antenna and signal processing work already mentioned. The CW and FM work on the other hand had tended to decline, with insufficient market drive to push it forward. However one of the most significant advances of the century, the widescale application of semi-conductor technology was still to come.

In 1948 the advent of the transistor had been announced from the Bell Laboratories in the USA and the whole of the electronics world began to look in that direction. By 1951 Eastwood had set up a semi-conductor research laboratory under the direction of I.G. Cressell and he with a number of colleagues began to grow germanium crystals and study doping techniques. Although the laboratories had some background in crystal growth from Parkin's work on quartz during and after the war, the techniques involved for semi-conductors were very different and like other UK workers the team had to build their experience virtually from scratch. New techniques for refinement and analysis were developed and small quantities of prototype devices made for evaluation by other units within the laboratories and by product divisions of the Marconi Company. All the early work was as in the rest of the world devoted to germanium but by the late 1950's the semi-conductor laboratory had extended its skills to the uses of silicon and, to a lesser degree, gallium arsenide. A manufacturing facility had also been set up within the English Electric Valve Company and was producing, inter alia, large area high current rectifiers to designs evolved by the Baddow Laboratories.

By the end of the 1950's much of the work of the semi-conductor laboratory was devoted to the support of a new factory set up as a collaborative venture between English Electric, Mullard and Ericsson. However this proved to be a relatively short term arrangement as by 1962 the collaboration was terminated following the acquisition of the Ericsson interest by the Plessey Company.

In 1954 R.J. Kemp moved from the laboratories to Chelmsford to become Deputy Engineer in Chief of the Marconi Company and Eastwood took over as

Chief of Research. In that year he set up another new activity, the Vacuum Physics Section, under the direction of G.D. Speake. Work on valves had ceased in Baddow at the end of the war, with most of the personnel having moved to Waterhouse Lane, Chelmsford to a manufacturing unit, which following the purchase of the Marconi Company by English Electric became English Electric Valve Company (EEV). Eastwood believed that there was a need for continued research work in vacuum physics, particularly to fulfil the need for small quantity specialised devices in radar. The team with support from the Royal Radar Establishment worked on devices for radar receiver protection (TR cells) and on noise tubes to be used as standards in receiver noise measurement. The first application of their devices was in radars for the 1,300 MHz band, developed by the Radar Division of Marconi and sold to a number of customers in the military surveillance and civil air traffic control fields. Devices for the 3,000 MHz band followed and, although discussions took place from time to time regarding possible transfer of manufacture to EEV the quantity demand remained small and customers' needs are still being met in 1985 from the pilot facility. Design and manufacture for new requirements was however passed to EEV and from the end of the 1950's only such research work on vacuum and low pressure gas discharge devices as was necessary to support systems research work by other units in Baddow was carried out in the laboratories.

A third physics-based activity, also started in the early 1940's and led by Dr R.J. Benzie, was concerned with the study of magnetic materials for use at microwave frequencies. Benzie, a wartime RAF colleague of Eastwood, had carried out research on magnetic phenomena for his D. Phil at Oxford and had taken up a teaching post at Exeter University. There he was sponsored by the Marconi Laboratories to study nuclear magnetic resonance which it was thought might, because of the narrow line width involved, offer a means of separating moving targets from the often much larger signals