REPORTS AND REMINISCENCES ABOUT RADAR RESEARCH

The History of Modern Physics 1800–1950, Volume 8: Radar in World War II

Henry E. Guerlac
Tomash and AIP, New York, 1987. xxviii + 1171 pp. $110.00 ($88.00, AIP members) hc ISBN 0-88318-486-9

Radar Days

E. G. Bowen
Adam Hilger, Bristol, UK (US dist. Taylor and Francis, Philadelphia), 1987. 231 pp. $28.00 hc ISBN 0-85274-590-7

Reviewed by Robert V. Pound

The emergency diversion of science to cope with the threat and the actuality of war is the subject of the two books under review. The introduction to *Radar in World War II* quotes MIT Radiation Laboratory alumni as saying, "The bomb ended the war, but radar won the war." The mobilization in the US and UK of scientists, especially physicists, to create that new radar technology was intensive. Their work not only contributed critically to the war effort but led to new fields of scientific research after the war. The organization and funding that allowed "big science" probably began with that experience.

The books overlap somewhat, but they have very different perspectives. *Radar in World War II* was written by the late Henry Guerlac, a professional historian of science. At the Radiation Laboratory at MIT he was the historian for Division 14 of the National Defense Research Committee, which had created the lab. (Incidentally, his "history" should not be confused with the 28 volumes of the Radiation Laboratory Series, which recorded in detail the lab's technical progress.) Guerlac's work originally formed a classified report to the government in 1946; only now has it become more widely available.

The book describes the background, the establishment and the work of the "Rad Lab" between its founding in October 1940 and its closing after VJ day. The first fifth of the book reviews the earlier development of radar by the US Navy, the US Army and the British. The British "Tizard mission" in September and October 1940 brought to the US the cavity magnetron, invented by John T. Randall and Henry A. H. Boot in the laboratory of Mark L. E. Oliphant at Birmingham University. In the mission's demonstration at Bell Labs the device so excited the US witnesses that within two weeks the NDRC established the Rad Lab to exploit it as a basis for microwave (initially 10 cm) radar. The recruiting of physicists—mainly nuclear in those first few weeks—continued through the following five years.

E. G. Bowen, the author of *Radar Days*, who was a member of the Tizard mission, played a major role in defining the initial projects. Guerlac describes these and the many other projects undertaken as the laboratory matured. One of the last was the complex Project Cadillac for the Navy—the forerunner of the Navy's "AWACS" (Airborne Warning and Control System). In the spring of 1944 an increase in atmospheric water vapor content was found to be increasing absorption of 1.25-cm waves, reducing the range of "K-band" radars being developed. This greatly lessened the enthusiasm for the production of these systems, which ranked among the most advanced developments at the time. The book's second part is devoted mainly to the operation of the many systems developed by the Rad Lab.

There is an enormous amount of detail, including a 700-name index. Much of this detail may be interesting primarily to alumni of the lab—such as myself. Inevitably and understandably, there are omissions. Especially in hindsight, it seems that the depth of understanding of the basic electronic theory of semiconductors, as developed in connection with microwave-diode rectifiers, receives less attention than it deserves. The transistor had not been invented, so the persistent importance of semiconductor properties was not realized when the book was written. This is not a book one is likely to read through page after page; one is more likely to consult it for reference. One may then find oneself diverted into reading much more than intended. Among the four introductions are two carried over from the original report and two written for this version. One of the latter was cowritten by one of the Rad Lab's most distinguished alumni, the late I. I. Rabi, and his biographer, John Rigden. [See the review of Rigden's book in PHYSICS TODAY, January, page 79.]

Radar Days is the much more personal autobiographical story of one of the chief technical contributors to the British development of radar. Bowen begins with radar's own beginnings in 1935 (under Robert Watson-Watt) and proceeds through the Tizard mission, Bowen's subsequent involvement in the founding of the Rad Lab, and his departure to help the Australian war effort at the end of 1943; a postscript covers his career in Australia after the war. Bowen tells a fascinating story of the first work at the bleak Orfordness, a marshy spit jutting into the North Sea from East Anglia, work that led to the design and construction of an extensive air-raid warning net using large meter-wave transmitters and antennas on towers. That system, known as the Chain Home System, became an important factor in the Battle of Britain. Soon after the decision to build that net, recognition of its potential for

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reducing the effectiveness of daylight bombing raids led Henry Tizard to anticipate that the enemy would turn to night bombing. The ground control system based on the warning net would be able to direct fighters to within four or five miles of an intruder, close enough to enable closure based on visual contact by day. But at night one could expect to see for no more than about 1000 feet.

With the encouragement of Watson-Watt, the project director, Bowen undertook to develop a radar system small enough to be carried in a night-fighter aircraft. This first effort to construct an air-interception radar led to several successive operational versions. The British began to install these systems in night-fighter aircraft before the war, when there was no source available for microwaves; they operated at wavelengths in the meter range. Bowen tells of demonstrating his experimental system, mounted in a two-place night-fighter, to prominent authorities in 1936. It was not easy to squeeze into the rear compartment such portly third riders as Winston Churchill, his friend and chief science adviser F. A. Lindemann (later Lord Cherwell) and Watson-Watt to share the seat with the radar operator—either Bowen or Robert Hanbury Brown. Bowen provides evidence of Cherwell's coolness toward radar, a part of an oft-described disagreement between Cherwell and Tizard. From the days after the impressive demonstration in the US of the operation of the pulsed-cavity magnetron at Bell Labs, Bowen tells an amusing anecdote of the accident that led to American magnetrons being made with eight cavity resonators, while the British had only six during the early months of manufacture.

We must be very grateful to Bowen for giving us a fascinating and personal account of the efforts of that small group of talented and dedicated men who so correctly anticipated the coming crisis and, by their constructs, gave others a chance to join in and finally to overwhelm a common foe. The book tells an important story with the authority, sensitivity and wit that only its main actor, Bowen, could provide.

Statistical Mechanics

Shang-Keng Ma
World Scientific, Singapore (Teaneck, N. J.), 1985. 548 pp. $74.00 hc ISBN 9971-966-06-9; $33.00 pb ISBN 9971-966-07-7

Shang-Keng Ma, formerly professor of physics at the University of California, San Diego, died in his home in La Jolla on 24 November 1983. He was recognized as a leading theoretical physicist and educator in statistical mechanics. He left many legacies to physics, among which was a book he had written in Chinese. The book, now translated, stands in the same relation to conventional graduate texts on statistical mechanics as does the two-volume treatise *Statistical Physics* by Lev Landau and Evgenii Lifshitz (Pergamon, New York, 1980). It is not a book to be used for a first reading of the subject—or even a second reading. However, it (potentially) exemplifies the "third-book rule": The third book a student reads on a subject is always the best! The topics treated demand rather more sophistication than is typical of graduate students—or of many experienced practitioners. Nonetheless there are gems in this book totally missing from standard texts on statistical mechanics.

But before discussing the gems, let us outline the book itself. It is divided into seven parts, with the headings Equilibrium, Hypothesis, Probability, Applications, Dynamics, Theoretical Bases and Condensation. In the introduction, Ma calls the first three parts "elementary" (rather an understatement) and the last four "more difficult." The introduction also sets the book's tone: a rare combination of depth of physical understanding and attention to concrete numerical facts. The introduction concludes with a disarmingly short list of very practical mathematical formulas, including a handful of extremely useful numerical relations (such as the fact that $2^{20} \simeq 1\,000\,000$).

This book avoids discussing the concept of ensembles, Ma having stated already in the preface that "the concept of ensembles is unnecessary and indeed not compatible with reality." This is not to say that Ma can establish the fundamentals of statistical mechanics on a new and firmer foundation. Rather, he considers statistical mechanics to be an "ill-proportioned subject, with many successful applications but relatively little understanding of basic principles." This humility before the fundamentals is characteristic of the presentation throughout the book. For example, he regards the basic assumption that a state occurs with a probability proportional to $\exp(-H/T)$ as a "rule for calculation"—a prerequisite for progress, but nonetheless an assumption devoid of justification.

Now to the gems: Having worked in both particle physics and condensed matter physics, Ma is adept at