emphasis on self-sufficiency, the isolation of its leadership from the economy and society, and Erich Honecker's stress in the '80s on consumption above all else ultimately led to fatal deterioration of the system. Historians and others will find this overview useful but should note that Bentley has a tendency to downplay the complexities of the issues he addresses. In describing the situation in the '50s, for instance, he does not mention that problems associated with overemphasis on self-sufficiency and isolated leadership had already arisen. Nor does he mention that some of the elements of the reformism of the '60s, in particular the emphasis on long-range, "perspective" planning and evaluating plant performance in terms of "profits," had already come into wide use in the earlier decade. Making sense of these apparent contradictions remains a task for future historians of GDR technology.

Chapters 4 through 6 are the heart of the book and assess the GDR's R&D infrastructure and its output on the eve of the country's collapse. Much of the material here is statistical. In less able hands, this may have been very dull indeed, but Bentley masters the statistics (rather than the reverse) and presents them in lively prose, supplementing them frequently with qualitative evidence.

Bentley's final chapter deals in part with the R&D potential of the "five new Länder" in what used to be the GDR. It is here that his analysis could be improved somewhat. The West German Science Council's 1991 assessment of the R&D potential of the former east was often much more positive than the picture Bentley paints. Admittedly, as Bentley argues, the Council investigated at the micro level, it was in part politically motivated, and it assessed potential rather than past performance. But Bentley shares its optimism about the long-term prospects of technology and research in the area of the old GDR. One wonders, then, what are the sources of such rich potential in such a disastrous system? Readers should be able to formulate plausible answers to this question on the basis of the material presented in Bentley's book, but direct and sustained attention to it from the author would have improved the book substantially.

This is, however, a minor flaw in a first-rate study. Bentley's book should have broad and long-lasting appeal to those interested in the problems and potential of the contemporary German political economy, to policy-makers, to scholars in technology studies, and to historians.

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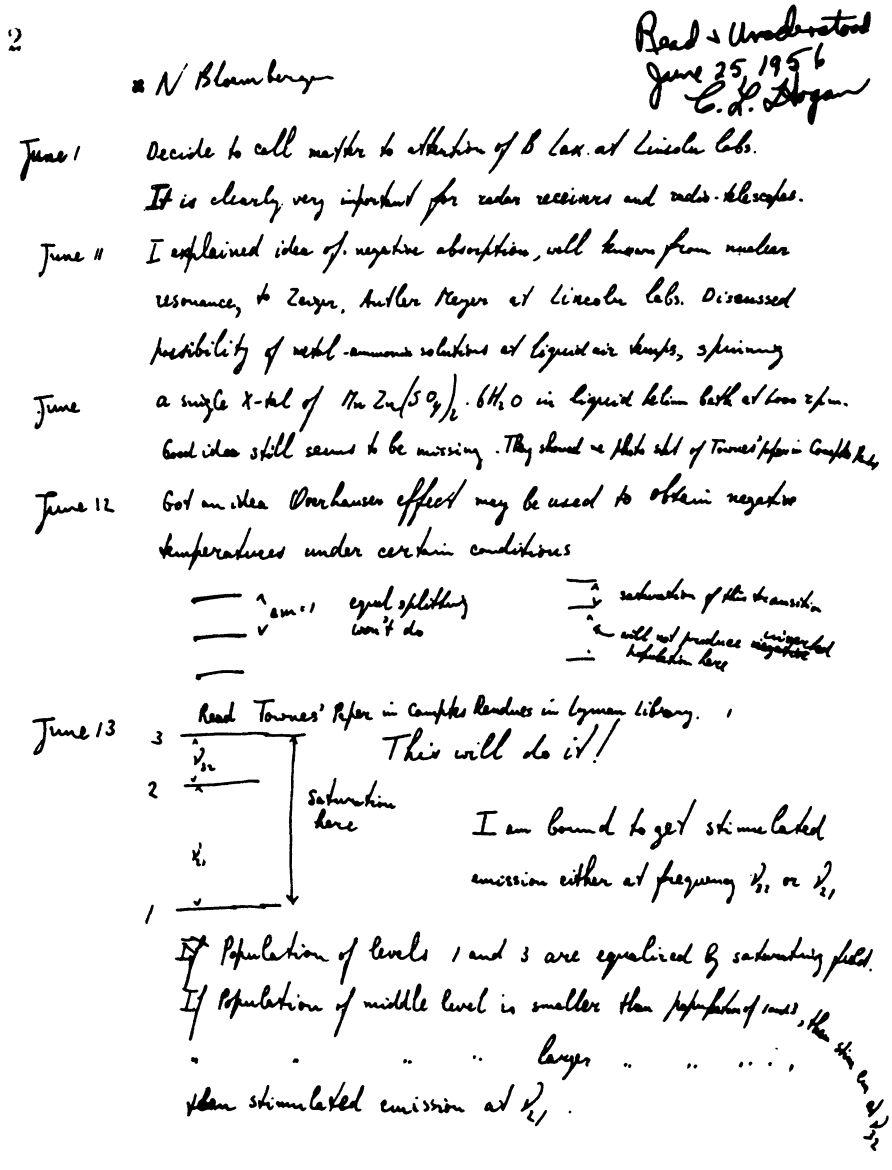
An Era of Electro-Optics

The Laser in America, 1950–1970. JOAN LISA BROMBERG. MIT Press, Cambridge, MA, 1991. xvi, 310 pp., illus. $32.

The laser is one of the great technological developments of this century. Based on a simple but elusive principle, it has found application in a wide variety of spheres from home entertainment to advanced military systems. A large cast of scientists and engineers contributed to the development, with many dramatic moments. The central part of this story is told in this thoroughly researched and clearly written book.

In 1982, four societies—the American Physical Society, the Quantum Electronics and Applications Society (now the Lasers and Electro-Optics Society) of the Institute of Electrical and Electronics Engineers, the Laser Institute of America, and the Optical Society of America—established the Laser History Project with historian Joan Lisa Bromberg as director.



A page from Nicolaas Bloembergen's 1956 research notebook. "On June 12 and 13 the 'good idea' came. He would use a molecular system with three unequally spaced energy levels and would pump systems from the lowest to the highest level, supplying energy at a rate that would make the number of systems in the highest state (level 3) equal to the number in the lowest state (level 1). . . . Then either the middle level (level 2) would have a smaller population than the other states, in which case he could get stimulated emission from level 3 to level 2, or it would have a larger population than the others, in which case he could get stimulated emission from level 2 to level 1. The fact that the pumping transition was divorced from the masing transition in the three-level maser allowed continuous action and lifted the limitation to materials with long reaction times." [From *The Laser in America, 1950–1970*; courtesy N. Bloembergen]

Bromberg conducted 50 taped interviews and numerous others, studied the published literature, and collected reports and laboratory notebooks to supplement the published material. All these records are available to scholars, but this book is Bromberg's distillation of the material, covering the most active period of laser development. Bromberg makes clear that she is concerned not just with the technical details of each development but always with the social context. In her preface she states, "I have chosen to write a book that is as much a study of the U.S. scientific establishment, as reflected in the light of laser research, as a study of maser and laser science and technology."

The beginning of the period covered, which coincided with that of the Korean War, found the Department of Defense and other government agencies eager to support new ideas and numerous newly formed industrial research laboratories looking for new directions for their explorations. The first chapter of the book sets this scene and also notes the changes in this background, both in the public mood and the defense market, that occurred in subsequent years. The second chapter describes the decade of maser development. Although of limited use at present, the maser was the precursor to the laser and hence the key element in the birth of quantum electronics. There follow three chapters on laser research and development, the first of these covering the evolution of laser concepts and the first operating lasers, the next describing the excitement of the period when new laser lines were discovered every day, and the third presenting case histories of the discovery of some of the most important laser systems and the growth of applications. A final chapter explores why it took so long for the laser to emerge from Einstein's 1916 explanation of stimulated emission and the factors that caused it to appear when it did. There is an epilogue by laser experts A. H. Guenther, H. R. Kressel, and W. F. Krupke giving a brief review of laser applications at the time of the book's publication, with some predictions for the future.

There are many dramatic moments in the stories of individual contributors. There is the conception of the maser by Charles Townes in 1951 while he was waiting on a Washington park bench for a DoD advisory committee meeting. There is Nicolaas Bloembergen's concept of the three-level maser, which made solid-state masers possible. The importance of the 1958 *Physical Review* paper by Arthur Schawlow and Charles Townes in setting down the conditions for laser action is made clear. Theodore Maiman's key contributions that made possible the first operating (ruby) laser are detailed. There is much more, all carefully researched and referenced, but the author is also interested in larger questions. In addition to that of why the laser took so long to appear there are others: Why did the maser come before the laser when many lasers are simpler? Why did so many different types of lasers follow so quickly after the first, and what were the factors causing the developers of these to choose their particular media? Why did successful operation of the difficult semiconductor laser appear almost simultaneously in four different laboratories?

Of the societal issues, Bromberg emphasizes the ease with which support for new ideas could be obtained at the beginning of this period. She is much interested in the role of government, industry, universities, and professional societies in the developments and in their interaction through consultancies, advisory committee service, and scientific and professional society meetings. Indeed, the motivational factors that made laser research attrac-

tive to the various institutions and the individual investigators are summarized in a table near the end of chapter 6. The difficulties in going from a concept for applications to a useful working system are detailed, and the contributions of physicists, chemists, engineers, materials scientists, and optical scientists, especially the cooperative aspects, are emphasized.

The book is clearly written. Bromberg gives explanations (without equations) of relevant physical principles, and some scientific literacy is required for full appreciation of the story she tells. Anyone, however, can appreciate the drama of the major discoveries, the successful and unsuccessful attempts to find applications, and the circumstances that made it all possible. There are numerous illustrations, mostly photographs of the principals in their laboratories, but also sketches of lasers, a few energy-level diagrams, and copies of key notebook pages. There is a comprehensive index and 50 pages of notes, most referencing the sources, but many providing glosses on the text, even to pointing out instances in which the advisory committee of the Laser History Project did not agree with the author's interpretations.

Perhaps the main limitation of the book is that made clear in the title—the concentration on the two decades between 1950 and 1970 and on work in the United States. There are occasional comments that extend beyond those limits, but they lack the detail given the primary material. Those familiar with Mario Bertolotti's historical account (*Masers and Lasers*, Hilger, 1983) will recall that he does take an international approach, and also devotes two chapters to the explorations of stimulated emission before the maser. His book, however, requires a scientific background, as he develops the laser principles quantitatively, together with the history. Although he went well beyond the published literature, Bertolotti did not have the considerable resources of the Laser History Project behind him, so could not be as detailed in the central portion. Thus the two books are complementary, each important in its own way. Bromberg's book is essential reading for anyone interested in the history of the laser itself or in the societal factors that shaped its development.

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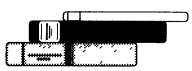

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