books

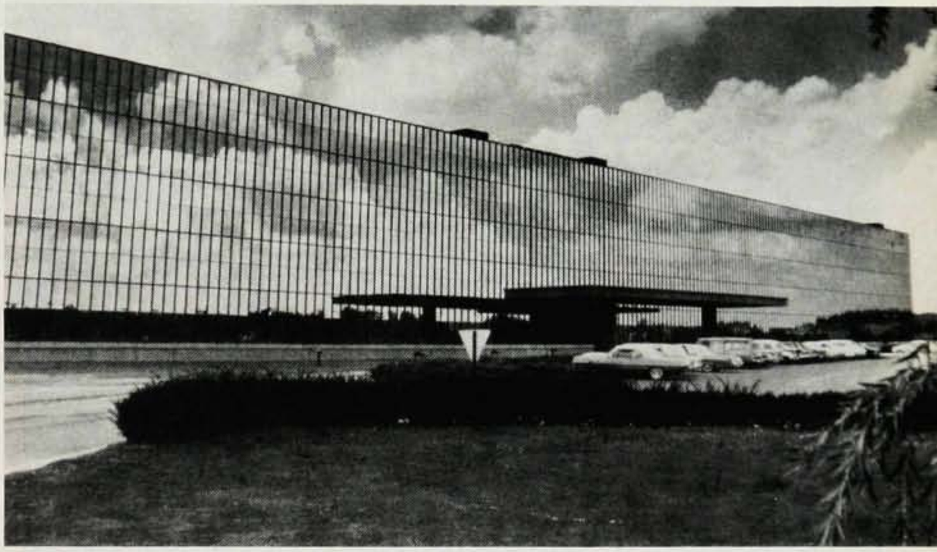
Research at Bell Labs: A comprehensive overview

A History of Engineering and Science in the Bell System

Edited by S. Millman

674 pp. AT&T Bell Laboratories, Short Hills, New Jersey, 1983. $30.00

Reviewed by Hendrik B. G. Casimir



Bell Labs building in Holmdel, New Jersey, is one of several Bell Labs facilities devoted to fundamental and applied research. This one is located on the site where Karl Jansky discovered extraterrestrial radio noise in 1932. (Bell Labs photo.)

Modern technology could not exist without the scientific knowledge created by research. Nowhere is this more obvious than in telecommunications. Knowledge about electric currents preceded the invention of the telegraph; knowledge about electromagnetic waves foreshadowed its application in radio communication; the discovery of the electron led to vacuum electronics; research on metals and semiconductors opened up the still rapidly expanding field of solid-state electronics and microcircuitry. Industrial laboratories were created to apply existing knowledge to technological problems and to add to basic knowledge on subjects that held promise for such application.

The Bell Laboratories have, ever since their beginning, been prominent among industrial laboratories. Their work has enriched science, and has also led to many innovations realized in the Bell system.

The present volume—one of a series, the members of which bear no number (a slightly awkward omission)—has the subtitle "Physical Sciences (1925–1980)," and is divided into two parts: one dealing with research in physics and the other with research in materials. The book is the result of a collective effort of as many as 75 authors. The general editor is Sidney Millman, a scientist well known for his work on hyperfine structure and on microwaves. Millman joined Bell Labs in 1949, and rose to the rank of executive director of research. The result is an outstanding account of a most impressive activity in many branches of modern physics, especially in solid-state physics and in quantum electronics.

Having expressed my admiration for this book and for the laboratories whose work it describes, I want to make a few critical remarks. The authors were compelled to condense a lot of material into short sections, and the result is not always satisfactory. Someone familiar with the subjects discussed will have to admit that the authors have succeeded in formulating the gist of the matter in a few sentences; but one may wonder whether these sentences will be very helpful to a newcomer. Much of the text is rather dry and does not convey the excitement that is an essential part of research. Such dryness is hard to avoid in a many-authored book. Millman mentions that the use of the UNIX operating system greatly facilitated the preparation of the various drafts. I am not familiar with that system and am quite willing to believe that it has contributed to a uniformly high standard of presentation. It may also, to a certain extent, have eliminated personal styles. Fortunately, a few sections—those about the transistor are an outstanding example—contain ample historical and personal detail, and these are very enjoyable.

The book gives fair recognition to the work in other laboratories—but, in general, only when it had a direct influence on the work done at Bell—and sometimes it fails to put things in the right historical perspective. Here are a few examples: The section on the microwave gyrator—a waveguide section with ferrites and absorbers arranged in such a way that it transmits centimeter waves in only one direction—mentions that this work was inspired by a paper of Bernard D. H. Tellegen in the *Philips Research Reports*, but it neglects to mention that an optical arrangement closely resembling the microwave arrangement (shown on page 47) was proposed many decades earlier by Lord Rayleigh. Similarly, in the extremely brief description of Harry Nyquist's important contribution to the theory of thermal noise in resistors, it is not mentioned that electric fluctuations—although not the details of their frequency spectrum—had been discussed before by Roman Smoluchowski and by Luberta de Haas-

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Lorentz. There is also no mention that thermal noise had not only been observed by J. B. Johnson, but also by others, using sensitive galvanometers. In the chapter on radioastronomy, the 21-cm line of atomic hydrogen is barely mentioned, although its study was for many years the main activity and even the main *raison d'être* of some radioastronomical centers. One more example: On page 144, reference is made to papers by N. E. Alekseevskii and Yu. P. Gaidukov, and by J. Yahia and J. A. Marcus, on the magnetoresistance of pure single crystals at low temperatures. These papers appeared in 1959. But even larger effects were found around 1930 by Aleksei V. Shubnikov and Wander J. de Haas, who studied very pure crystals of bismuth. The book is a reliable source of information on what went on at Bell Labs. It is not—nor does it claim to be—a history of the subjects treated, although in many cases the research at Bell Labs is a major part of the history.

The shortcomings mentioned—perhaps I should call them unavoidable limitations—are, to a certain extent, compensated by the "Overview" preceding each of the two parts. The overviews are written by Albert Clogston and William Slichter, respectively. And, as a proud summary of summaries, we find on page 18 a table listing "Contributions to Communications Science and Technology Growing out of Physics Research at Bell Laboratories." The extensive lists of references at the end of each chapter should also be mentioned. They will be most useful to readers who want to study a topic in greater detail.

In the foreword, N. Bruce Hannay, vice-president for research (now retired), sets forth the basic principles on which Bell Labs have been operating. It is well worth reading, the more so because we are living in a period in which research budgets are under heavy pressure almost everywhere and a lot of talk about research planning and management is going on. Hannay emphasizes that the Bell Labs have a clearcut mission, namely to develop new communications technology and to allow the Bell System to provide better and cheaper communications services. But this mission is interpreted in a broadminded and farsighted way. There are many possibilities for personal initiative and individual preferences, and no attempt is made to measure the value of each particular piece of research in terms of ensuing commercial profits. I should like to quote several passages, but I restrict myself to one.

> Stability and continuity in Bell Laboratories support for research have been essential to its health. Sufficient resources have been placed at its disposal to allow it to do what was needed to stay at the forefront of knowledge. And understanding of the peculiar nature of the research environment and needs of research people has characterized the institution. Part of the reason for the success of Bell Laboratories research is that the research managers understand these things; they themselves have all risen from the research ranks, but only after they have demonstrated a superior ability to do research themselves. People of this kind are most able to maintain the respect of and successfully guide an outstanding research staff.

In short, this is a valuable book. Few physicists will feel tempted to read it in one stretch from cover to cover, but many will turn to it again and again because of the wealth of information it contains. I think it should—and I hope it will—be carefully studied by all those dealing with research management and research funding.

Empire of Knowledge: The Academy of Sciences of the USSR (1917–1970)

Alexander Vucinich
482 pp. University of California Press, Berkeley and Los Angeles, 1984. $29.95

Alexander Vucinich's study is essentially a history of the conflict in the USSR between the views that science develops on the basis of the practical needs of society and that science develops according to its own inner logic—a conflict between the Communist Party and the scientific community seeking autonomy in its domain.

Vucinich is a historian of science at the University of Pennsylvania. His major work has been on science in Czarist Russia, but he has extended his research into the Soviet period as well. He tends to blame the political structure of the USSR for the controversies that arise, ignoring, for example, that in the US every request for major research expenditures must be supported with arguments about the ultimate practical consequences of the research without references to needs of the inner logic of science.

Vucinich divides the history of the Academy into four stages. From 1917 to 1928, the ideological influence was "fragmentary and without clear direction." The second and third stages, from 1929 to 1945 and from 1946 to 1956, were dominated by a massive effort to make the unity of science and ideology a strategic component of national unity through purges of nonconforming scientists, attacks on scientists