Langmuir's Work: Physics, Chemistry, and Engineering, Intimately Intertwined

It is probable that very few, except those who knew Irving Langmuir intimately, have any conception of the range and scope and the thoroughness of his many contributions to chemistry and physics during his active years, which were essentially the first half of the 20th century. I believe these volumes, *The Collected Works of Irving Langmuir* (vols. 1–12. C. Guy Suits, General Ed. Harold E. Way, Executive Ed. Pergamon, New York, 1961–62. $15 each; $150, the set), are the largest and most important publication of collected works yet issued for any American scientist, and as such the collection is of great importance.

Volumes 1 through 9 are devoted to reprinting Langmuir's published scientific papers; each volume also contains one or two essays, written by experts in the field, on the subject matter of the contents of that volume. Volumes 10 and 11 give a full presentation of his work on atmospheric phenomena, cloud seeding, and meteorology, and these volumes contain much hitherto unpublished work in this field in addition to his previously published papers. Volume 12 is about half taken up with a biography entitled "The Quintessence of Irving Langmuir," written by Albert Rosenfeld, science editor of *Life*; the remainder of the volume is given over to Langmuir's papers and speeches on general subjects, and includes his address as the retiring president of the American Association for the Advancement of Science, "Science, common sense, and decency" (1943).

Langmuir was born in 1881 and died in 1957. He received his undergraduate degree from the School of Mines of Columbia University and his Ph.D. under Walther Nernst at the University of Göttingen. After three years of teaching at Stevens Institute of Technology, Langmuir joined the staff of the then newly organized research laboratory of the General Electric Company, where he remained extraordinarily active for the rest of his life.

The collection opens with general summarizing essays by Sir Eric Rideal and the late Percy Bridgman, on the chemical and physical aspects of Langmuir's work, respectively (these essays are also reprinted in volume 12). Volume 1, *Low-Pressure Phenomena*, has a more specific essay, by S. Z. Roginsky of the Academy of Sciences of the U.S.S.R., on Langmuir's work on gas kinetics. This carries into the papers in volume 2, *Heat Transfer–Incandescent Tungsten*, on heat transfer and the researches that led to the gas-filled tungsten, incandescent lamp and to hydrogen arc welding. The appreciative essays are by E. R. G. Eckert and Zay Jeffries.

Volume 3, *Thermionic Phenomena*, is concerned with thermionics and the effects of adsorbed films of thorium and cesium on electron emission, and also with the discovery of the laws of space-charge limited emission. The appreciative essay is by J. A. Becker of the Bell Telephone Laboratories. Volumes 4, *Electrical Discharge*, and 5, *Plasma and Oscillations*, which have introductory essays by J. D. Cobine of General Electric Research Laboratory, are taken up with Langmuir's large contributions to the fundamentals of electric gas discharges and with his pioneering work on plasma, an area that today is the object of much attention. It would probably save vast sums of money if most of the men now working on plasmas in government contract laboratories would stop work and devote a few months to the careful study of Langmuir's papers.

Volume 6, *Structure of Matter*, is devoted to the papers on atomic structure and on the structure of solids; it contains an introductory essay by David Harker. In the period roughly from 1916 to 1926, chemists were quite dissatisfied with the inability of the original Bohr model of the atom to provide an adequate understanding of the nature of chemical valence forces. Following on ideas of W. Kossel in Germany and G. N. Lewis in Berkeley, Langmuir dealt extensively with the interpretations of chemical valence in terms of a static model of the atom; this concept was a forerunner of many of the features of the present model in which the electrons exist in static standing-wave pattern states.

Volume 7, *Protein Structures*, volume 8, *Properties of Matter*, and volume 9, *Surface Phenomena*, are taken up with various aspects of surface chemistry. Volume 7 contains an essay by Harry Sobotka and deals with the work, much of it in collaboration with Dorothy Wrinch, that Langmuir did on protein structure. Volume 8 contains an essay by Henry Eyring, and also Langmuir's papers on the structure of solids and liquids and the fundamental studies of interfacial phenomena, including his Nobel lecture of 1932. This outstanding honor crowned Langmuir's work in surface chemistry. Volume 9 contains essays by N. K. Adam and by W. A. Zisman and presents in full the papers on the kinetics of evaporation, condensation, and adsorption; it also contains the great program of work on monomolecular films, which was carried out in collaboration with Katherine Blodgett.

Volume 10, *Atmospheric Phenomena*, includes Langmuir's World War II researches on smoke filters and smoke generators and has an introduction by V. J. Schaefer. Volume 11, *Cloud Nucleation*, is devoted to cloud seeding and weather control and has an essay by Horace R. Byers. As Byers says, "From this point on (1951) Langmuir's work was descriptive, speculative and in all cases controversial. Some of the heat of battle is revealed in the Final Report." This is one of the hitherto unpublished papers that makes a valuable addition to the meteorological literature, no matter what may be the final judgment concerning details of the work.

In criticism of the biography in volume 12, *Langmuir, the Man and the Scientist*, it needs to be said that it gives a fine anecdotal picture of the personal and family life of Langmuir, but it fails to give a picture of the economic and technological importance of Langmuir's work. We are told about his low salary during his early career when he was teaching, but never once do we get any concrete idea of the value to industry of Langmuir's work or of the economic rewards that were given to him. Nor was the technological story all smooth sailing: there were some spirited battles over contested patents, and a full account would tell about them.

Particularly interesting to the general reader are the accounts of Langmuir's trip to Russia in June 1945; these are given in chapter 22 of the Rosenfeld biography in volume 12 and also in Langmuir's own account which starts on page 379 of that volume, and again in his "Discussion of Science Legislation," which was his testimony in October 1945 before a Senate committee about bills to establish a national science foundation. His testimony on atomic energy control starts on page 365; but there must be an error in the date, there given as 30 September 1945, because the McMahon committee did not get organized until about the first of November. (In the complete list of papers, which is noted in each of the 12 volumes, this paper, entry Number 202, is dated 30 November 1945.) In any case, this testimony is noteworthy for his having said, "If, in this way, an atomic armaments race develops, I believe the Russians will produce their first atomic bombs in about 3 years." This was at a time when General Leslie Groves was saying it would take them 20 years. It actually took four. The testimony also contains Langmuir's story of the bumbling efforts of Groves to prevent the scientists from going to Russia. This extended to interference with British participation in the conference which aroused indignation in England, where Langmuir says, "I also heard the opinion expressed that this action must have been taken at the request of the American Government because no one outside of the American Army could be so stupid."

Finally let it be recorded that for books priced at $15 a volume, the printing and binding are disgraceful. There are so many misprints and confusing, misspelled names that one wonders if anybody read proof. The printing abounds with broken and misaligned type. Each volume repeats the general introduction by Guy Suits, and each contains the *same* portrait of Langmuir as a frontispiece, in spite of the fact that there must be many photographs of him that could have been used, for Langmuir was a handsome photogenic personage.

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Instruments and Techniques

Stars and Stellar Systems. Gerard P. Kuiper, General Ed. vol. 2, *Astronomical Techniques.* W. A. Hiltner, Ed. University of Chicago Press, Chicago, 1962. xxi + 636 pp. Illus. $16.50.

Almost all of our knowledge of the stellar universe comes from the analysis of electromagnetic radiation that is collected by optical or radio telescopes, detected by the eye, the photographic plate, the spectrograph, or the photoelectric cell, and then measured and analyzed by a variety of techniques. This volume is concerned with the techniques of the instruments of detection, with the measuring devices, and, finally, with the reduction and analysis of the observations. Volume 1 of the series dealt with the telescope itself. The present volume is limited essentially to optical, earth-bound techniques, and little is written of solar, rocket, or satellite instrumentation and nothing of radio astronomy.

The book is enthusiastically recommended to the professional astronomer and graduate student. The 24 chapters are written by 26 different authors. Although some of these chapters will soon be outdated in the rush of technological progress, probably half of them should remain classics for years to come. There are chapters on the spectrograph and the photoelectric photometer, photomultipliers and the photographic plate, the measurement of faint sources, radial velocities, magnetic fields, and polarizations. There are four chapters on photometry and spectrophotometry; three on television tubes and image orthicons and converters; three on the reduction of photoelectric observations; four on astrometry. The final three chapters are concerned with orbit methods for visual, spectroscopic, and eclipsing binaries. The only serious omission is that of interference filter photometry, which has been developed so successfully by Strömgren and his students. By fixing photoelectric attention on spectral lines and regions that are not only sensitive to temperature and absolute magnitude effects but also to effects of chemical composition and age, this method holds tremendous promise of quickly giving us deeper insight into the basic facts of stellar evolution. Undoubtedly the technique should be modified so that numbers of slots of proper width and spacing are placed in the focal plane of a coudé spectrograph. Strangely enough, observatories in this country are lagging behind those abroad—Cambridge University, for example—in this kind of development and its very exciting possibilities.

This book gives strong testimony to the great stimulation given to new instrumentation by the existence of large telescopes located in excellent climates. An even greater stimulation will soon come when orbiting observatories go into action. But as the editor so properly puts it: "A mastery of earth-bound techniques and their application to observational astronomical research is imperative for fruitful exploration with both old and new, unpredictable, developments." This country is committed to space research to the tune of tens of billions of dollars, with the result that we have an appalling shortage of trained astronomers, men thoroughly familiar with spectroscopic and photometric techniques, who know what needs observing and with what. It is truly an emergency situation that seems to be little appreciated by either the National Aeronautics and Space Administration or the National Science Foundation. The best way to train observational astronomers is well known—with modern telescopes of moderate size, located in good climates. Of the dozen or more top graduate schools of astronomy in this country, only the University of California at Berkeley and California Institute of Technology have such telescopes, so located. The American Astronomical Society has nine times awarded the Helen Warner Prize to the best young astronomer. Graduates of Berkeley have won it five times and those of Cal Tech twice. It seems abundantly clear that what is needed—and as quickly as possible—is a goodly number of moderate-size, modern telescopes, located in good climates, for *all* of our top graduate schools, with the responsibility for the telescopes and the instrumental development and operation definitely allotted to specific schools. These schools already have an abundance of students, but a large majority of such students lose heart and turn to other fields, when they discover what they have to cope with in the way of obsolete and inadequate instruments and nearly impossible weather conditions. It is quite possible to run a mile race in