

Lawson on beams: the definitive text

The Physics of Charged-Particle Beams

J. D. Lawson

462 pp. Clarendon (Oxford), New York, 1977. \$37.50

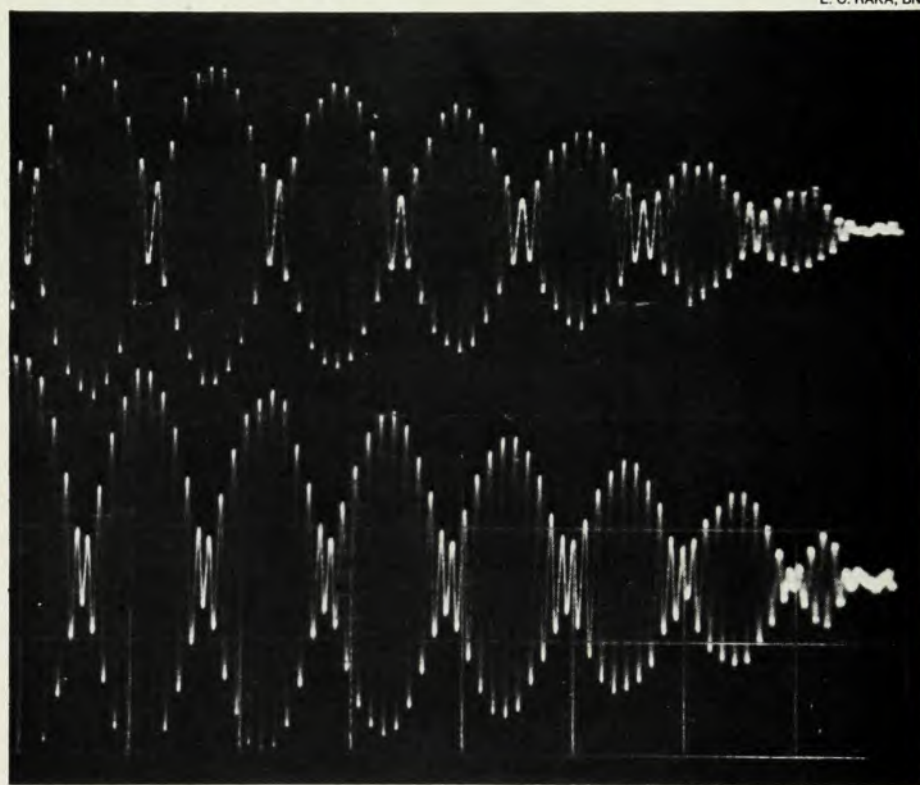
Reviewed by John P. Blewett

When we are presented with a book by John Lawson on charged-particle beams, we have every reason to expect an opus that is clear, well-organized, comprehensive and, in a word, definitive. The author has not let us down; the book is satisfying to read and a valuable addition to the shelves of anyone concerned with the behavior of charged particles.

Lawson has spent most of his thirty-odd-year career in British research organizations beginning with TRE Malvern, the radar establishment emerging from World War II. Here he became acquainted with the problems of microwave devices, particularly radiation from radar antennas. Then his primary attachment became the Atomic Energy Research Establishment at Harwell, later the Rutherford Laboratory when it separated from AERE. This is still his affiliation, but during the past two decades he has taken an intense interest in plasma physics and fusion problems, spending a couple of years at Culham. This interest resulted in the famous "Lawson criterion," a simple inequality that defines the level of plasma density and duration that must be maintained before a self-sustaining fusion reaction can take place. In the course of his career he has delved intensively into all of the important aspects of the behavior of charged particles, in single particle orbits, in the presence of space charge and under the influence of various concentrations of plasma.

A beam, as defined by Lawson, is an assembly of charged particles moving in a direction approximately parallel to the beam axis (which may be curved) and with an energy distribution of less than a few percent. His treatment proceeds from the clear and comprehensible to the complex and barely understandable.

The clear and simple part relates to beams sufficiently rarefied that interactions between particles can be neglected.



Excitation of coupled oscillations of an unbunched beam in the Alternating Gradient Synchrotron at Brookhaven National Laboratory is shown by horizontal and vertical pick-up electrode signals. Linear coupling is described in J. D. Lawson's *The Physics of Charged-Particle Beams*.

Lawson develops the paraxial-ray equation for a number of special cases, presents focusing systems and the concepts of ion optics, and derives basic orbits in particle accelerators.

He introduces space charge in the idealized case of "laminar flow" in which the velocity distribution at a point is single valued and orbits do not cross. As the reader will find out later, this does not happen in nature; but it provides a convenient and *anschaulich* procedure for introducing the effect on the individual particle of the collective field due to the charge in the rest of the beam.

We now are ready to study non-laminar beams and to be introduced to the concepts of beam emittance and brightness. This leads to the treatments of I. M. Kapchinsky and V. V. Vladimirovsky and of A. A. Vlasov. Lawson gives passing notice to his own work with Pierre Lapos-tolle and Robert L. Gluckstern on the

analogy between emittance and entropy.

Specialized systems including scattering and dissipation are the next topic; the discussion covers electron cooling and relativistic electron-storage rings with the attendant effects due to emission of synchrotron radiation.

Finally the book includes a compact yet comprehensive discussion of waves and instabilities in particle beams. Lawson first introduces the reader to waves in plasmas, an approach that will be unfamiliar to accelerator theorists but one which is very illuminating. Eventually he treats the various instabilities observed in accelerators—longitudinal, transverse and bunched beam effects.

The total content of the book relates to beams in space or possibly surrounded by conducting walls that support image currents. The field of interaction of beams with matter—multipactor effects,

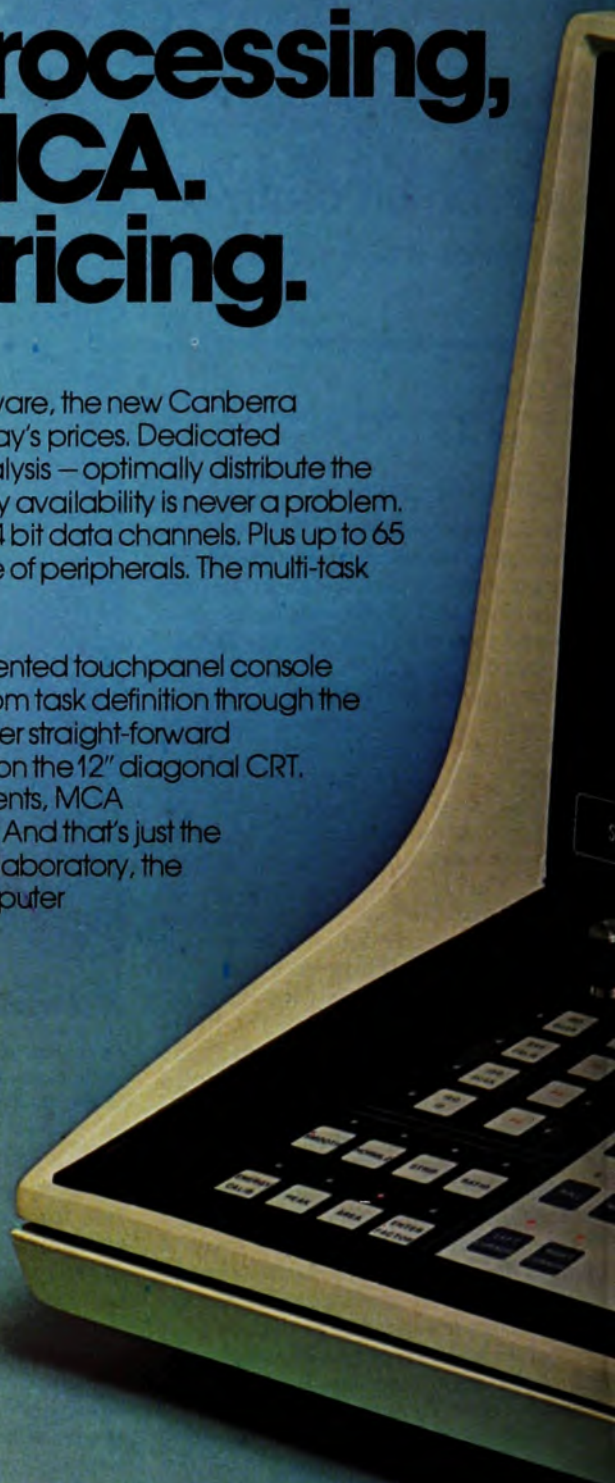
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secondary emission and so forth—are not considered and, indeed, would be inappropriate topics in such a book.

A few critical remarks seem appropriate although they do not detract appreciably from our overall view of the sterling quality of the book. The quality of the printing is not commensurate with the importance of the text. The pages are merely reproductions of typed manuscripts without justified margins. It seems that we could expect more than this from the Clarendon Press. Both text and equations contain a number of misprints; no doubt these will disappear in the sec-

ond edition. Also the author is sometimes a bit cavalier in his use of symbols. After we have become accustomed to the use of ϕ to represent a potential, it suddenly appears as an angle.

Every reviewer will find that Lawson's favorite list of references does not correspond exactly with his. This reviewer missed a couple that he felt might well have been included: William C. Hahn's 1948 paper on "Effects of Hydrostatic Pressure on Electron Flow in Diodes" and the series of papers by Rena Chasman in which she solved the mystery of emittance growth in linear accelerators.

These criticisms, as we have said, are not of great importance. This book will continue for many years to be our favorite work on charged-particle beams.

* * *

John P. Blewett is a Senior Physicist at the Brookhaven National Laboratory, where he has been associated for three decades with programs on design and construction of particle accelerators.

Physics and the Sound of Music

J. S. Rigden

286 pp. Wiley, New York, 1977. \$12.50

Music, Speech and High Fidelity: A Descriptive Acoustics Worktext

W. J. Strong, G. R. Plitnik

360 pp. Brigham Young U.P., Provo, Utah, 1977. \$9.95

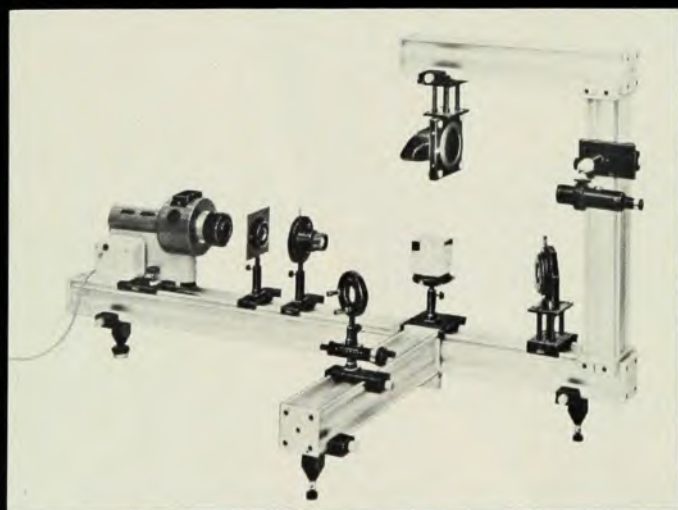
The reflowering of musical acoustics in the past two decades has joined with the economically induced increase in physicists' interest in teaching non-physics students to produce a musical-acoustics course at practically every college in the nation. The liveliness of the teachers of such courses has been legendary among those of us who are active in musical-physics research. The lack of a substantial choice of textbooks has been a continuing problem for all these instructors.

Alexander Wood's classic was aimed primarily at the science student, and has become outdated. John Backus's standard *Acoustical Foundations of Music* (Norton, 1969) is up-to-date, but once again serves a constituency somewhat toward the science side of the student spectrum. Other textbooks for many years have been clearly derivative, and not too trustworthy. In this desert, many were led to use the reviewer's lighthearted 1960 paperback as a reference source. More recently his *Fundamentals of Musical Acoustics* (Oxford U.P., 1976) has appeared, to pursue the musician relentlessly, but again the general student is left malnourished. It is therefore a distinct pleasure to welcome two excellent, but very different new textbooks to the field of music-related acoustics. Both are certain to find warm ecological niches in the classroom. The book by Strong and Plitnik will also find its way into the reference shelf of every teacher and of every researcher in the fields to which it addresses itself.

John Rigden's graceful book introduces itself as being for the nontechnical reader who enjoys music and wishes to learn

update design!

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