

BOOKS

Elementary particles, by David H. Frisch and Alan M. Thorndike (Princeton, D. Van Nostrand Company Inc., 1964; \$ 1.75), is the first of a series of reasonably priced paper-back books (*Van Nostrand Momentum Books*) published for the Commission on College Physics in the U.S.A.

The series, so we are told, was conceived 'to serve the modern enquiring mind. Scientist, engineer, teacher, student, inquisitive layman... each will find that *Momentum Books* provoke new ideas, new questions and new answers while they provide an insight into experimental techniques and the disciplines of the scientific mind'. From this it can be inferred that the authors do not set out to give an exhaustive treatment of their respective subjects, and the book under review confirms this impression. It is both entertaining and instructive to those who have some appreciation of its subject matter, but it is not in itself a complete treatment of elementary particles.

Indeed, the authors make this clear in their preface, where they state that the topics discussed are only representative 'and there are unsubstantiated assertions on nearly every page'.

The first seven chapters deal with some of the facts of elementary-particle physics. In the first, a few of the more 'bizarre' notions serve as an introduction to the subject, followed by a brief history, from the Greek 'atom' to the present day (or, to be exact, the latter part of 1962). This is followed by a chapter on 'Particles we surely need' — graviton (?), photon, electron, pi-meson, proton, neutron and their antiparticles — and one giving brief accounts of the various ways of detecting particles. 'Particles we might do without' comes next, these particles being those whose existence is forced on us by experimental evidence although a simple theory of nuclear and atomic behaviour would not require them — particles such as muons, neutrinos, kaons and hyperons. The next chapter deals with ways of measuring the charge, magnetic properties and mass of elementary particles, and the following one with some elementary-particle reactions. Much of this, in fact, is devoted to a dramatic first-hand account of the experiment in which lambda hyperons were produced artificially for the first time and the hypothesis of 'associated production' was confirmed. The last chapter of this section describes in some detail how the existence of the antiproton was proved experimentally.

In reading this part of the book, one or two things stand out especially. For example, at the beginning of chapter 2 an elementary particle is defined as 'one we do not know how to describe as composite'. This may sound rather defeatist at first sight, but it certainly explains the proliferation of such particles in recent years as well as the consequent belief that there must be some underlying order that will enable all the presently known particles (as well as others to come) to be described in terms of only a few. In the section on the measurement of masses, the use of magnetic fields and electric fields as momentum filters and energy filters, respectively, for beams of charged particles, is clearly shown. Historically, there are also interesting reminders. The pion with which we are so familiar in our work at CERN was first produced artificially only in 1948; antiprotons have been known for only ten years and the

experiment that provided 60 examples to prove their existence needed a new accelerator (the Bevatron) before it could be carried out, besides new identification techniques that have now been developed to provide beams of these antiparticles with intensities of tens of thousands of antiprotons per second. In the cloud-chamber experiment on hyperons, some 4000 pictures were taken on the first day and 20 000 in the whole run, compared with today's typical bubble-chamber run of a quarter of a million pictures at the rate of 25 000 a day.

Chapter 8, as the authors state, is rather more abstract, dealing with the important subject of the forces between elementary particles. Gravitational forces, electromagnetic forces, scattering experiments, the quantum idea of electromagnetic forces, nuclear (strong) forces and the weak forces of radioactive decay are all dealt with in an enlightening way. Chapter 9 also deals with an abstract subject, but one that has currently become of particular interest: conservation laws and invariance principles. The relation between these two concepts is clearly explained, using as examples the conservation of linear momentum, of angular momentum, and of energy, the reversibility of time, the conservation of parity, the conservation of electric charge, charge conjugation, the conservation of leptons and baryons, and finally the concepts of isotopic spin and strangeness. The non-conservation of parity in weak interactions is very well described, with the aid of clear helpful diagrams, and the discussion of CP invariance (assumed here, of course, to hold for all interactions) helps to show why its apparent violation in recent experiments has caused such a stir. The book is worth reading for this chapter alone.

One of the deeper reasons why the study of elementary particles has such an attraction is demonstrated in the discussion of the laws of conservation of lepton and baryon numbers. There is no explanation for these laws, yet if they did not exist the proton could decay into a pion and a positron, there would be no nuclei, no atoms, no molecules, and no physicists to wonder about the cause. The last chapter is devoted to some of the attempts to bring order out of the chaos of experimental data now available. Unfortunately progress is so rapid that few of the approaches discussed have retained much interest, except as steps on the road to current ideas. On the other hand, the four major questions with which the book ends still seem as far from being answered today as they were when they were written.

A.G.H.

Controlled thermonuclear reactions, by L.A. Artsimovich (New York, Gordon and Breach, Science Publishers, Inc., 1964; \$19.50).

A few months ago (May 1965) we had occasion to note in this column that plasma physics is a relatively new and very fascinating field of research. One of its main potential applications lies in the use of plasma to maintain a fusion that would produce controlled surplus energy. The world has seen a long series of machines all designed to produce fusion energy or to help studies of plasma mechanics with this aim in view (Stellarator, DCX, Ixion, Perhapsatron, Zeta, etc.). None of the projects so far has been entirely successful. It is true that one has been able to prove the occurrence of fusion in some plasmas for short periods (measured in milliseconds) but much remains before a

plasma 'heat factory' is constructed that can be switched on at will for any period of time.

The principle is to heat a suitable gas — such as deuterium or a mixture of deuterium and tritium — to a temperature where a fusion reaction (such as $d + d \rightarrow {}^3\text{He} + n$) takes place with sufficient abundance. The heating is effected by an electrical discharge, which partly ionizes the gas into plasma. This heat, as well as heat generated by the fusion, must be distributed in some way among the particles, preferably according to Maxwell's distribution law. At the same time, heat lost by radiation must be limited. The main problem, however, is the unwanted cooling of the plasma by the walls of its container. At present, the most promising way to overcome this seems to be to design a magnetic field of such an ingenious shape that all charged particles are caught by it and never touch the walls (hence expressions like 'magnetic bottles', 'mirror machines', and so on). But experience shows that, however subtle the arrangements, the plasma always manages (sometimes in conspiracy with the electric field) to break its way out through the magnetic field lines and get destroyed. It does so by constructing magnetic fields of its own, based on its charged-particle motion and by shooting out particles with the right energy at weak spots of the 'bottle'. These phenomena are called instabilities ('pinch', 'kink', etc., depending on shape). The failure to produce a 'canned' fusion has even led theorists to search for laws that would prohibit stable, isolated high-temperature plasmas in principle!

It is natural that the question of magnetic confinement of plasmas takes up a major part of this book by L. A. Artsimovich, a pioneer of Russian plasma research. In the

first three chapters, the principles mentioned above are discussed and equations of particle motion and diffusion are treated. The concept of magnetohydrodynamics with plasma waves is dealt with in the next chapter. The remainder of the book is dedicated to the theory and application of discharges and the heating and confinement of plasmas, with many examples. In particular, the last two chapters deal with magnetic confinement and its theory, and instabilities, giving a large number of machines and attempted configurations as examples.

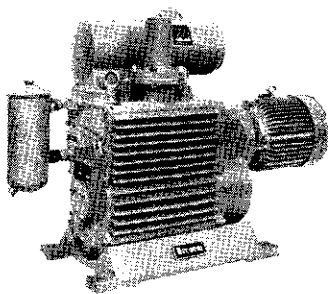
The style of the book (translated by P. Kelly and A. Peiperl from the Russian edition of 1961, revised and augmented by the author and edited by A. C. Kolb and R. S. Pease) makes it very clear and easy to read; this fact, together with the logical reasoning and richness of examples, makes the work an excellent text-book. As it is very complete it may also serve with advantage as a reference book for its subject. One regrets to say, however, that the author has used the older Gaussian c.g.s. system of units, which makes numerical work somewhat difficult and sometimes unnecessarily obscures underlying fundamental connexions (for example, by confusing the magnetic flux density $\vec{B}$, with the magnetic field strength $\vec{H}$). The index is sufficient, but not very detailed. There are no exercises given.

K. Soop

Also received:

Introduction to quantum mechanics, by P.T. Matthews (Maidenhead, Berks, McGraw-Hill Publishing Co. Ltd., 1963;

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Recent research on beta-disintegration, by A.I. Alikhanov (Oxford, Pergamon Press Ltd., 1963; 20 s.) - translation from the Russian edition of 1960; describes the experimental research in the field of beta-disintegration, carried out during 1957-1959, which established the laws governing the non-conservation of parity in weak interactions.

The dynamics of conduction electrons, by A.B. Pippard (New York, Gordon and Breach Science Publishers Inc., 1965; paper \$ 1.95, cloth \$ 4.95) -- text of lecture notes of early 1961, with appendix giving reference to later literature; semi-classical approach aimed at the student of experimental physics rather than the theorist.

Group theory and solid-state physics, vol. 1, edited by P.H. Meijer (New York, Gordon and Breach Science Publishers Inc., 1964; \$ 5.95) -- vol. 7 of *International science review series*, presenting reprints or English translations of selected papers contributing importantly to the understanding of the role of group theory in physics, with the emphasis on solid-state physics.

New physical and chemical properties of metals of very high purity (New York, Gordon and Breach Science Publishers Inc., 1965; \$ 24.50) -- proceedings of the symposium held in Paris in 1959 at the 'Centre national de la Recherche scientifique'; subjects covered include analytic methods, properties of very pure metals, and improvements in zone-melting techniques ●

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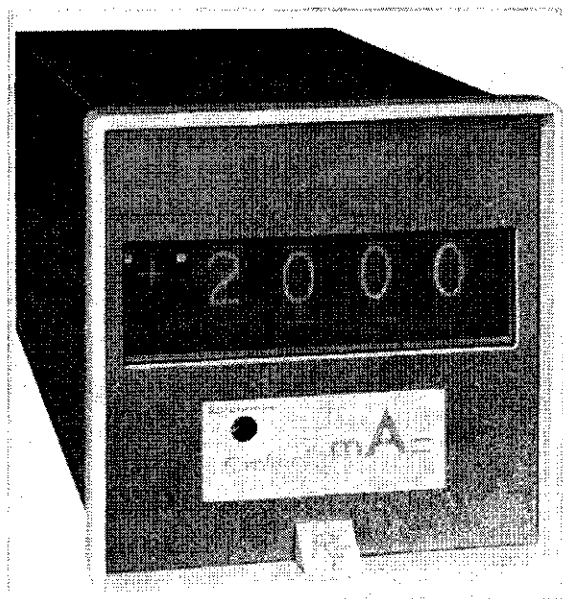
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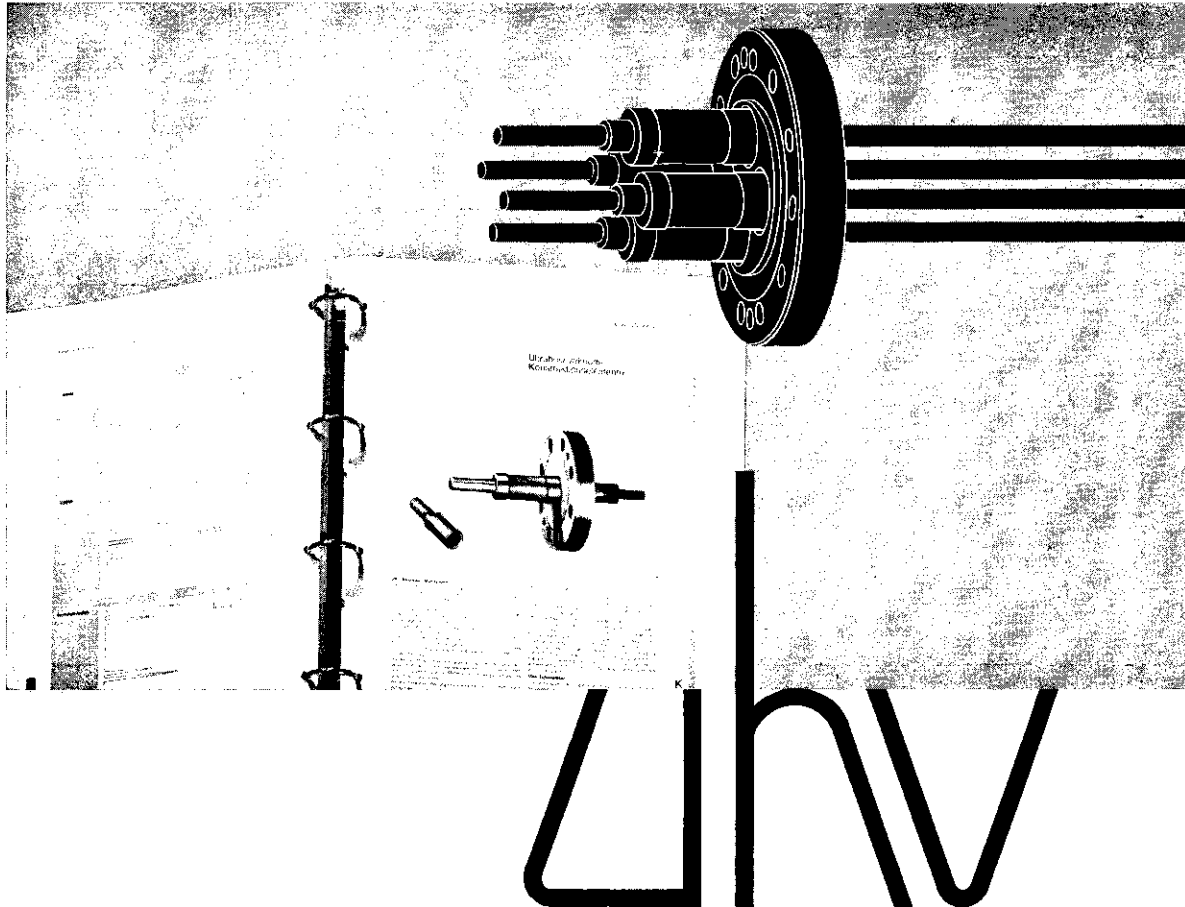
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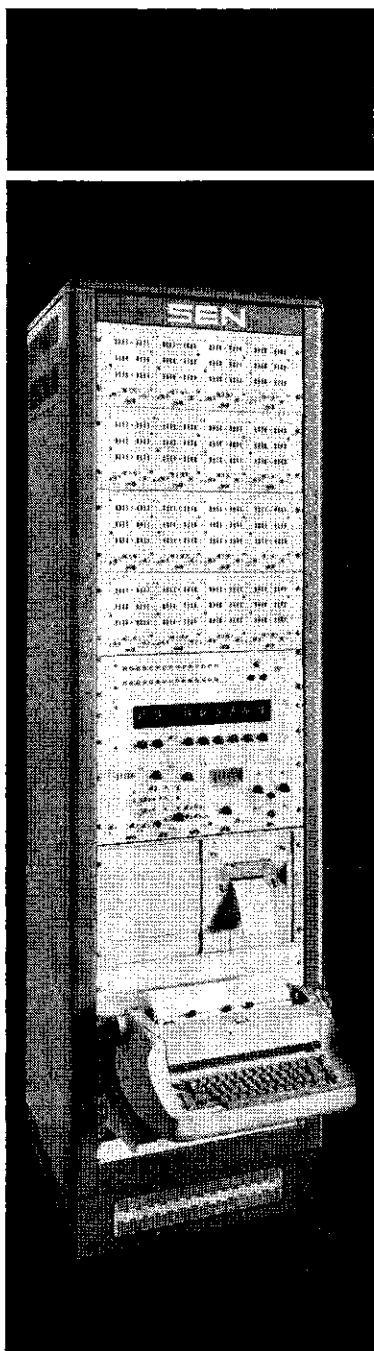
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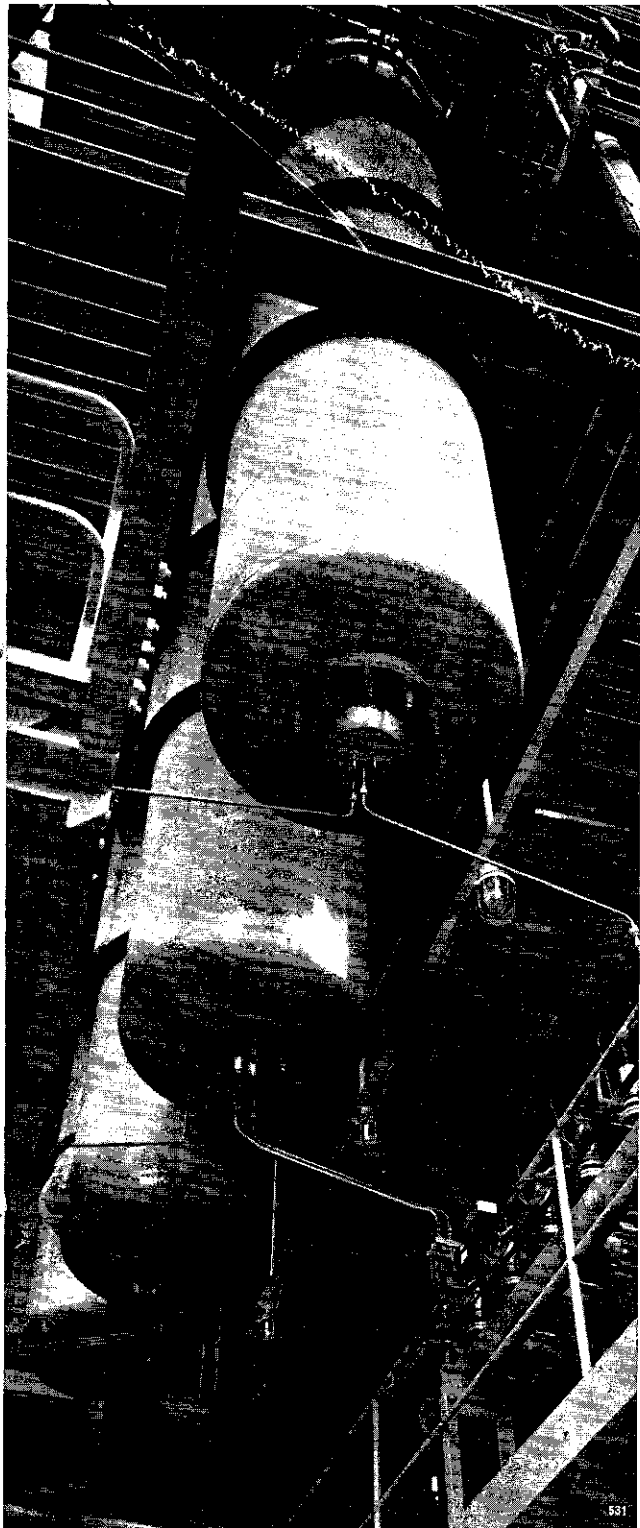
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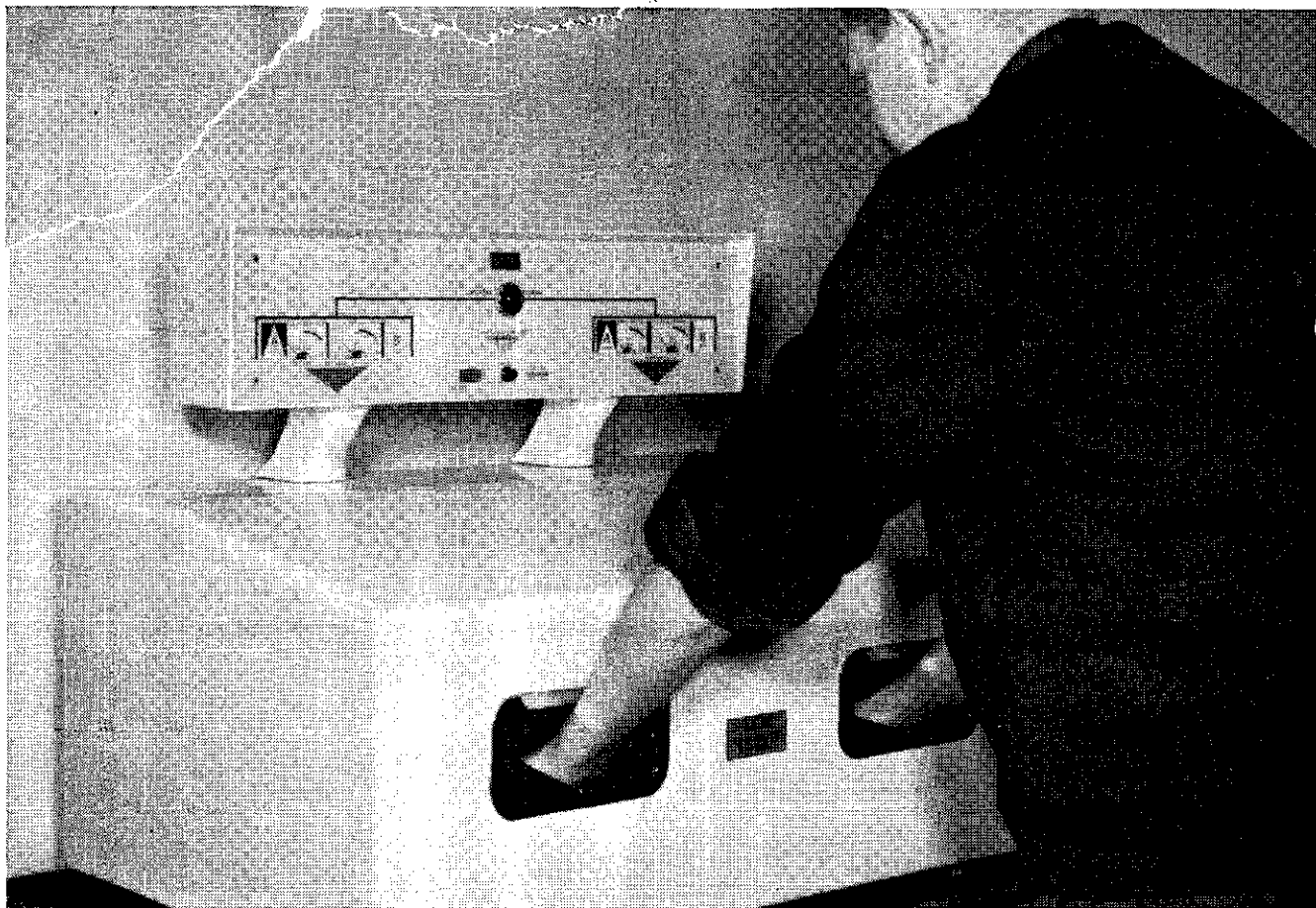
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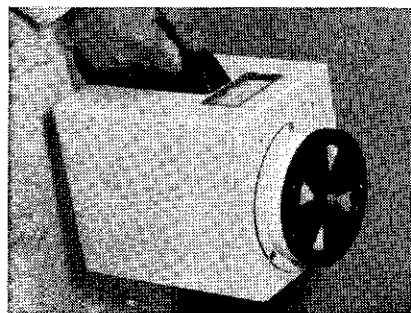
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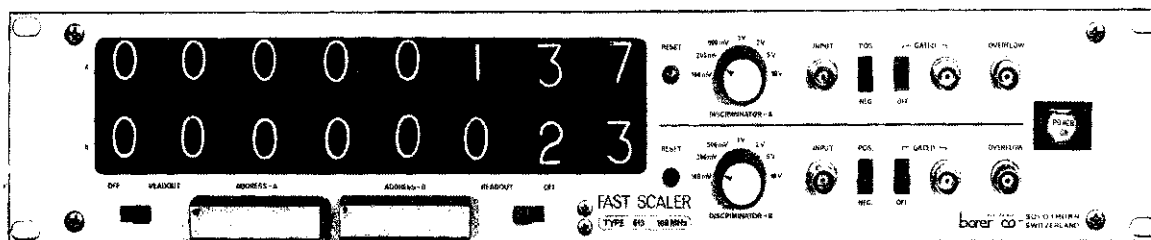


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