

BOOKS

The Feynman lectures on physics, vol. I — mainly mechanics radiation, and heat, by Richard P. Feynman, Robert B. Leighton and Matthew Sands (Reading, Mass., Addison — Wesley Publishing Co. Inc., 1963; \$ 8.75).

In recent years physicists, first in the United States and then in Europe, have been taking a very hard look at the way in which their subject is taught in schools and universities. Indeed, one of the things that has come under scrutiny is the very idea that physics is a 'subject', somehow separate from mathematics, chemistry, or biology, or from history, economics or foreign languages. A new idea (which, after all, is only a very old idea in modern form) has arisen, seeking not only to remove the rigid sub-divisions into which the study of physics has been split but also to present physics as a part of the knowledge that we all ought to have of the world we live in, something essential to a full education and not as an esoteric subject for a relatively few specialists. Specialists there must be, of course, and they will study physical phenomena in much more detail, but even specialists should remember that what they discover are explanations for human experience. As such, this knowledge has at some stage to be fitted into the everyday context of life, together with that of other sciences and of the arts, and not kept separate. Even at the frontiers of knowledge, in sub-nuclear research as at CERN, for example, where the behaviour of the 'things' we study seems so far from normal life, physics cannot be shut off from the various aspects of engineering, chemistry, biology, economics, languages, politics, and so on, that are all involved.

Nevertheless, at any level of teaching, not only historical inertia and the dictates of a workable timetable but also a certain natural grouping ensures that 'physics' will still be treated independently, though its relationships with other disciplines will be emphasized more than in the past. To this end a number of good text books have appeared which contrast strongly with even the best of those that were current, say, twenty years ago.

One of the most compelling must certainly be this one, edited under the direction of Profs. Feynman, Leighton and Sands and recording in vivid fashion the lectures given by Prof. Feynman to the first-year students of the California Institute of Technology in 1961-62.

As explained in the Foreword, this volume (the first of three) covers the first year of the two-year introductory course taken by all incoming students at the Institute and constitutes a major part of a fundamental revision of the course, carried out over a four-year period. Prof. Feynman prepared and delivered the whole series of lectures, which were tape-recorded, and the text-book for future use was prepared from the recordings — after an editorial revision that turned out to be much more arduous than was (perhaps somewhat naively) originally expected!

A study of the contents list, giving the titles and subtitles of the 52 lectures which have become the 52 chapters of the book, shows immediately that this is no ordinary text-book of physics. As one slowly reads through the book (and it takes a long time because there is a year's instruction in its pages) this first impression is reinforced again and again. The physics is certainly that which has

been taught for many years in the last terms at school and the first at university, supplemented by more recent knowledge. But the topics are in a different order, which gives the physics a new shape, there are examples and cross references that give it a new clarity, and the language is of a kind that separates the more important from the less important and compels a new enthusiasm for parts of the subject long since dismissed as dull.

The tone of the book is set in the first two pages. In these opening paragraphs, Prof. Feynman explains that physics cannot be taught as a set of axioms like Euclidian geometry; firstly we do not know all the basic laws and secondly the statement of those we do know requires a knowledge of advanced mathematics as well as some very unfamiliar ideas. Physics has to be learnt gradually, and everything we learn is only an approximation to the truth so that corrections will be needed later. Stressing that the test of all knowledge is experiment, he points out that it is *imagination* that is needed to create the great generalizations that are moulded into the laws of physics*.

Then he puts the proposition, that if all of scientific knowledge were to be destroyed and only one sentence passed on to the next generation, then the statement that would contain the most information in the fewest words would be the following: 'All things are made of atoms — little particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon being squeezed into one another'. All through the book this fact is not lost sight of. Even though many of the topics dealt with do not involve the idea of atoms explicitly, always the question is asked: 'Is what we have said consistent with what we know about atomic behaviour; if not, why not?'

To begin with, the first three chapters are of a general nature: atoms in motion, basic physics, the relation of physics to other sciences (chemistry, biology, astronomy, geology, psychology). Here there is no mathematics to put anyone off and this section in particular can be thoroughly recommended to anyone, not just the physics student, who would like to know what physics is.

Next comes a chapter on the conservation of energy, again a touchstone to be used many times to gauge the sense of a statement or derivation. Having often sought to define 'energy' for the sake of non-physicists, it was something of a relief to find here the confirmation that it does not exist in little blobs and in fact we have no knowledge of what energy is! 'Time' is a similar abstract notion, impossible to define specifically ('how long we wait', says Feynman) yet essential in our thinking and therefore needing to be measured in an accurate and agreed fashion. Both time and distance are dealt with in chapter 5, and the chapter following is devoted to a discussion of probability, not forgetting its relation to atomic structure and the Heisenberg uncertainty principle.

The next eighty pages or so develop the topic of Newton's laws of motion, beginning with the theory of gravitation, discussing what we mean by motion and how it is described

* Since this review was written, the selection of Prof. Feynman as one of the Nobel Prizewinners for 1965 has given recognition to his own eminence as a theoretical physicist.

by the mathematics of the calculus (differentiation and integration), the components of velocity and force, the conservation of momentum, vectors and vector algebra, different kinds of forces, including (already!) nuclear forces, and ending with the ideas of work and potential energy.

Next, and this is another surprise for someone brought up in the old tradition, come chapters on the special theory of relativity, relativistic energy and momentum, and space-time, the latter including a clear treatment of four-vectors and four-vector algebra — the logical extension into the four dimensions of space-time of the three-dimensional vectors already discussed. It seems obvious that this is the place to introduce these ideas. As presented by Prof. Feynman, they are not so terribly difficult and they show how Newton's laws have to be modified when the velocities involved approach those of light. Even Einstein's equations are still approximate, since they do not take account of the uncertainty principle, but they are not as approximate as Newton's equations dealing with the same phenomena.

From the mathematical refinements of essentially point-like particles, the lectures turn to the realities of solid bodies at the sort of speeds normally encountered, deriving such concepts as the centre of mass and moments of inertia and treating various aspects of rotation in both two and three dimensions, using vector notation.

The chapter entitled 'The harmonic oscillator' is introduced by the excellent explanation that the standard examples (mass suspended from a spring and simple pendulum) are to be seen as easily understood demonstrations of the properties of the highly versatile linear differential equation with constant coefficients, rather than as particularly interesting phenomena in themselves. A beautifully devised chapter on 'algebra' leads to the relationship between complex numbers and the 'geometrical' notation for oscillations in terms of sines and cosines, and thus enables such things as resonances and transients, in both mechanical and electrical systems, to be treated relatively easily in the following pages.

In the second half of the book, the first thirteen chapters deal with various aspects of electromagnetic radiation, a sort of synthesis between geometrical and physical optics and electrical wave theory that brings out the essential unity underlying these former sub-divisions of physics. Fermat's 'principle of least time' is used as the basis for a study of geometrical optics, and justified by quantum-mechanical considerations (again this cross-checking from one concept to another for consistency). Maxwell's equations introduce the topic of electromagnetic radiation, with all the phenomena of interference, diffraction, dispersion, absorption, polarization, and so on, that this involves, whilst the discussion brings in many of the ideas on the calculus, vectors, oscillations and quantum behaviour dealt with earlier. The section is brought to an end by one chapter on the relativistic effects of radiation and two that (at the moment!) are not physics at all, on the sensations of colour and the more general mechanics of seeing. Prof. Feynman rightly makes no apologies for 'these excursions into other fields'. 'Nature is not interested in our separations', he says, 'and many of the interesting phenomena bridge the gap between fields'.

There is also a sort of postscript, in which two chapters are devoted to an elementary discussion of quantum

mechanics and the question of the relation between the wave and particle viewpoints. At the same time this acts as a bridge to the next section, which begins with the kinetic theory of gases, passes through the principles of statistical mechanics, Brownian movement, application of the kinetic theory, and diffusion, to the laws of thermodynamics, devotes a chapter to some of the applications of thermodynamic theory, and ends with a chapter entitled 'ratchet and pawl'. In this, a model of good teaching, Prof. Feynman takes a simple piece of mechanical equipment, known to everyone, shows that it is not so simple as it looks, and thereby derives some of the essential ideas concerning reversibility and irreversibility that are at the heart of fundamental physics.

The next four chapters deal with various aspects of sound, serving as specific examples of some more general phenomena that arise from wave motion and supplementing the earlier chapters on electromagnetic waves. Included in this section is a statement of the important synthesis given by the idea of 'linear systems', and a consequent relationship between our ways of thinking about macroscopic waves, on the one hand, and quantum-mechanical atomic and nuclear systems on the other.

In the last chapter, Prof. Feynman's clarity of exposition, coupled with humorous presentation, is again shown to the full, and this explanation of 'symmetry in physical laws' is, like the opening chapters of the book, accessible to many more readers than just the students to whom it was first delivered. After defining what we mean by symmetry in such a context, and giving some of the more obvious examples, he deals with the remarkable connexion that exists between symmetry rules and conservation laws. He then considers some of the interesting properties of mirror images, including the particularly surprising fact that many biological systems distinguish between 'left-hand' and 'right-hand' molecules, so that many substances which can be made artificially in both forms exist in nature in only one. The difference between polar and axial vectors is also clearly explained.

In his highly entertaining story of the Martian who was told by telephone how to make a model of a man on Earth, Prof. Feynman shows clearly how the symmetry laws come into play and describes the connexions between the non-conservation of parity in weak interactions, antimatter, and the so-called CP invariance (though, perhaps typically, he doesn't name the latter as such).

Finally, in the last paragraphs, he turns to broken symmetries, giving a glimpse of problems with which physicists in high-energy laboratories are now so familiar.

A really adequate impression of this lively, sometimes provocative, and very personal approach to a major part of physical knowledge would require another Feynman as reviewer. All I can really say, in summary, is that anyone who has ever reached the stage of studying physics at university level should get the book for himself and explore its contents. He will be extremely well rewarded.

A. G. H.

Introduction to radiological health, by Hanson Blatz (Maidenhead (U.K.), McGraw-Hill Publishing Co. Ltd., 1964; 99 s.).

This book forms a very good introduction to the variety of problems associated with the field of radiation protection

— or radiological health, as the author prefers to call it. It discusses radiation and radiation sources, and their properties, as well as the problems of the interaction of radiation with matter; it also deals with biological effects, related to permissible radiation doses, contamination levels, radiation measurements, and protection, including radiation accidents and the legal aspects of radiation control.

The book is written in general terms, but it gives a considerable amount of information on its subject. It would be more useful as a volume of general interest to someone who wishes to gain some knowledge of the character and scope of radiation protection, rather than as a reference book for a health physicist. It is to be recommended to those who have some background in physics, biology or medicine and who would like to learn what the problems of radiation protection really are.

The book has a good subject index.

J. B.

Nuclear physics, by Irving Kaplan (Reading, Mass., Addison-Wesley Publishing Company Inc., Second edition, second printing, 1964; \$ 15).

The first edition of this well-known book appeared in 1954, and the first printing of the second edition dates from 1962.

Part I (7 chapters) deals with the 'Background of nuclear physics', including chapters on the special theory of relativity and on atomic spectra, part II, called 'The nucleus', is devoted mainly to radioactivity and nuclear reactions, while part III (4 chapters: neutron physics, nuclear fission, nuclear energy sources, and accelerators) is a choice, as indicated by its title, of 'Special topics and applications'.

Each chapter is followed by a list of references and — with one exception — by several (6-20) problems, the solutions being given in an appendix. The references are divided into two parts: general (mostly books), and particular papers quoted in the text. Many classical books and papers are included, which — if consulted — would serve to give the student a 'feeling of history'. Generally the references stop at 1958; only in a few places are there some items up to 1961, obviously 'added' at a later stage.

Many numerical tables in the main text and the appendices enable the student both to solve the problems and to become familiar with the orders of magnitude of the quantities involved and with the most important and characteristic physical data. As a separate enclosure a chart of the nuclides, up to lawrentium 103, contains valuable information, such as abundances, activation cross sections, modes of decay and energies, some isomeric states, and masses on the carbon-12 scale. This is the only place, incidentally, in which this scale is used explicitly.

As stated in the author's preface the book is intended for an advanced undergraduate level. Generally speaking, from this point of view the choice of topics is reasonable, although the complete absence of elementary-particle physics is a limitation, even if the book is addressed mainly to non-physicists and particularly students of nuclear engineering. From the present text, in fact, it is rather difficult to guess for what useful purpose the high-energy accelerators described in the last chapter might have been built. The

'curriculum' of the book may also explain why spark chambers or solid-state detectors are not even mentioned; nevertheless, this must be seen as a serious gap today.

Obviously it would be quite unreasonable to provide the text with more than a rather descriptive treatment of theoretical problems involving quantum mechanics, such as (for example) alpha-decay or parity conservation, and the reader who wants to acquire a better understanding and a deeper insight must make use of the literature, to which, it is true, he is generously and judiciously sent by the references.

A few minor negligent formulations might give rise to erroneous understandings. For example, on p. 156 one finds: 'The spin angular momentum of the electron... could have the values $+1/2$ or $-1/2$...', when in fact, in opposition to its projections, the spin itself is characterized by essentially positive quantum numbers.

As a whole, however, the book is written in a clear-minded and attractive manner, able to stimulate the beginner's interest in nuclear physics and its applications. Its reputation as a most valuable introduction to nuclear physics is well deserved. Let us hope that a further edition, which will become necessary presumably in the not too distant future, will not only be brought up to date but will also include an elementary account of high-energy physics and fundamental particles.

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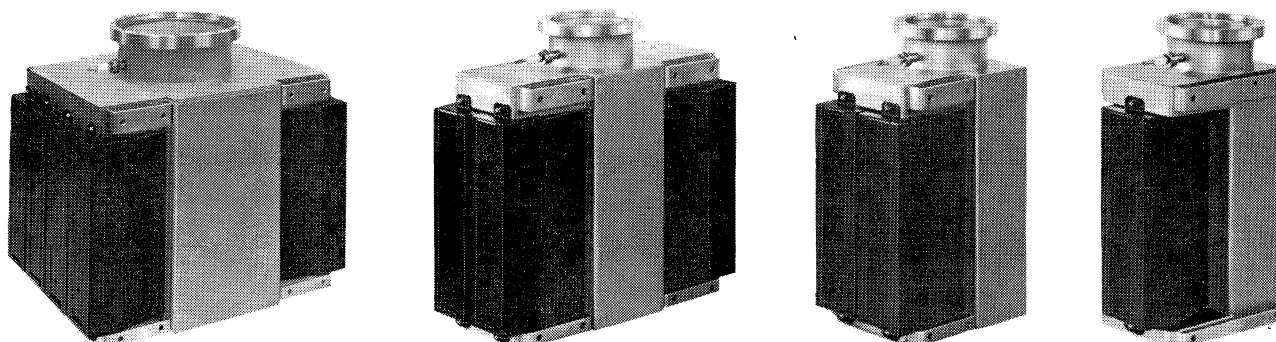
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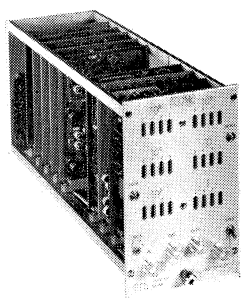
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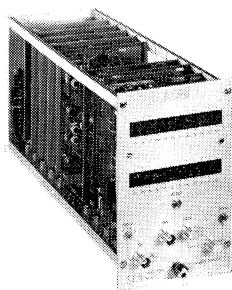
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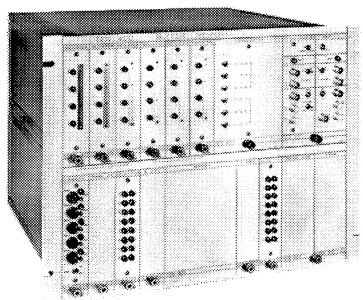
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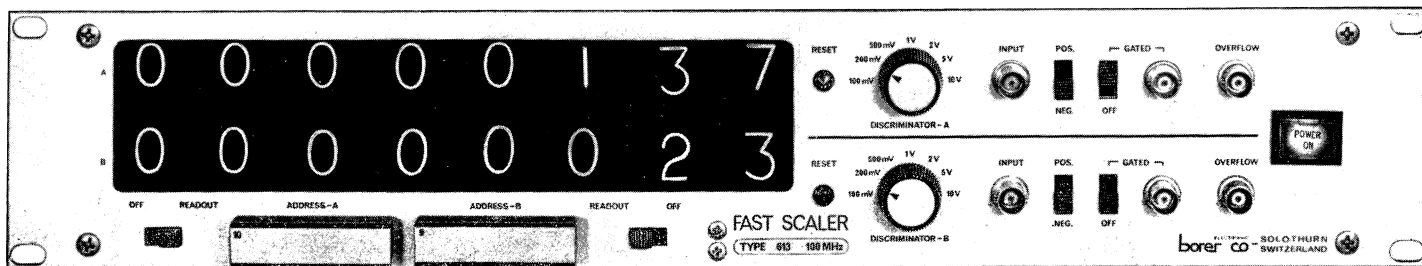
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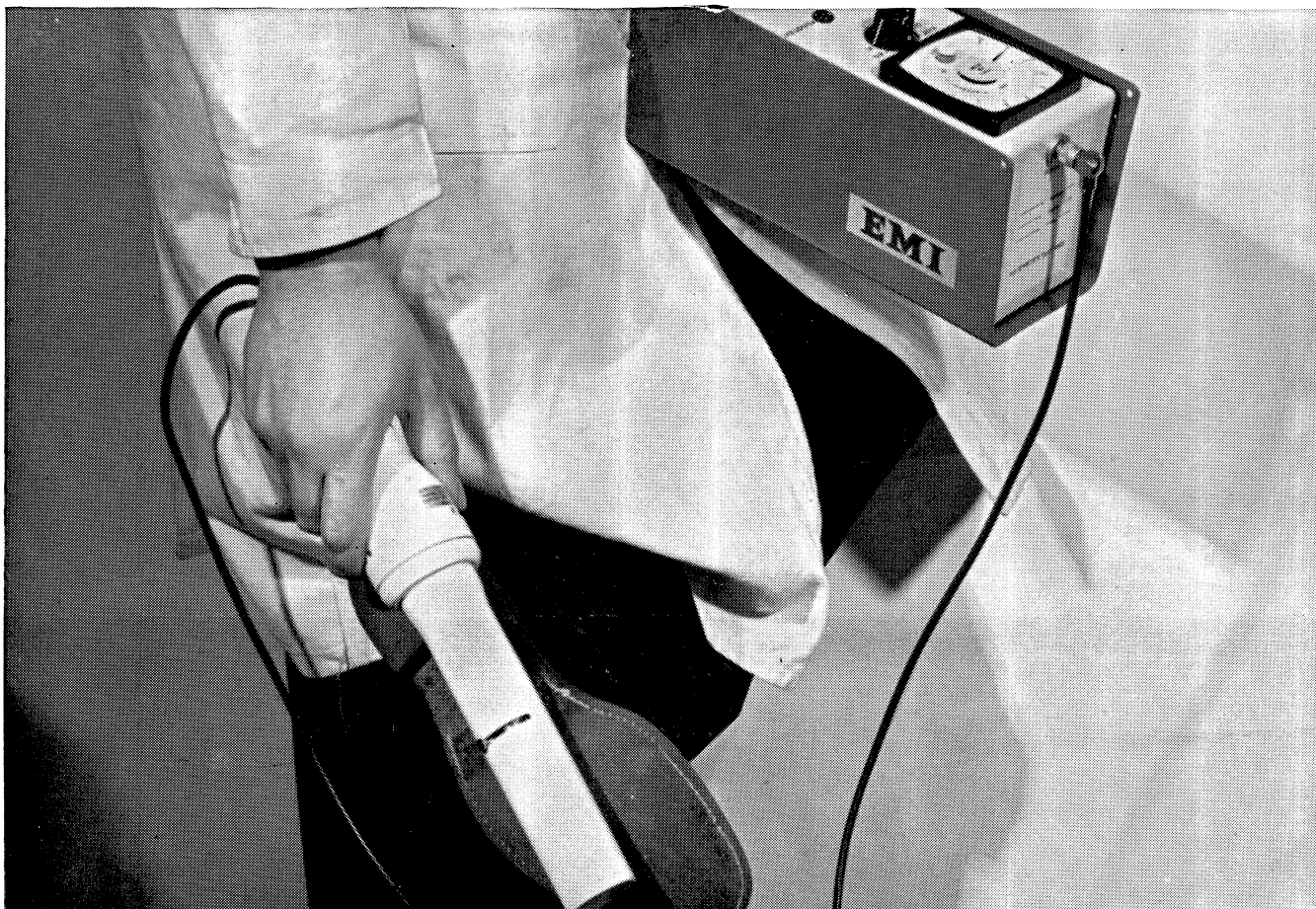
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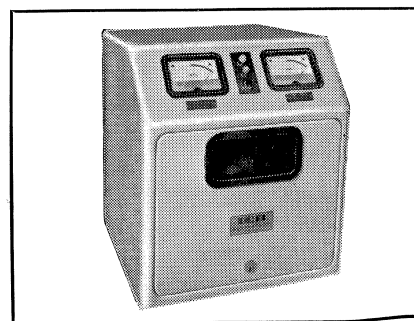


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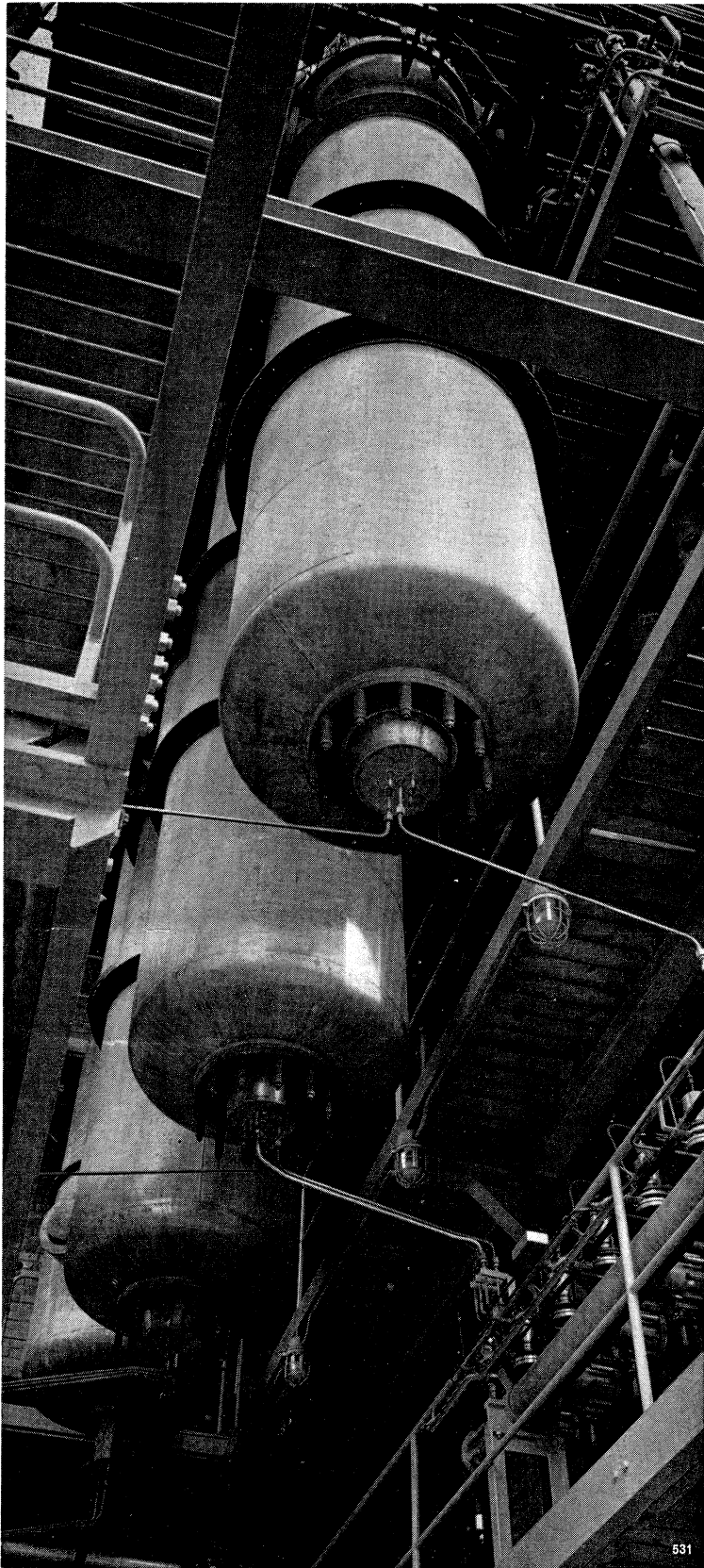


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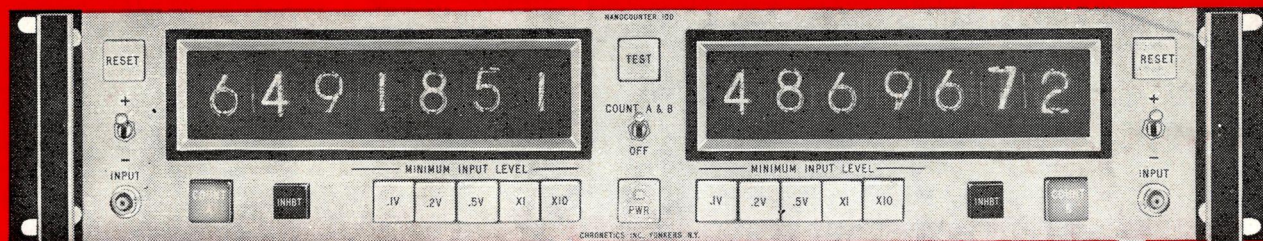
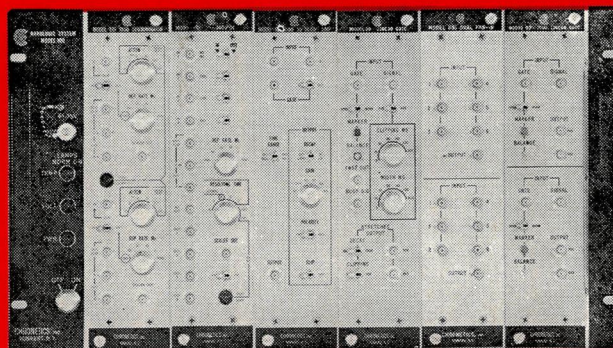
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