pendices, one dealing with the computation of rotation operators in terms of spherical functions and the other with the elements of group theory.

The English translation of Dr. Messiah's admirable treatise should be well received by the scientific community, especially, by those not well versed in the French language. The translation has been skillfully executed and, in so far as it is possible, both the style and contents faithfully follow the original text. The publishers and the translators deserve the gratitude of the readers, especially of the students and teachers. Indeed, it is difficult to find a superior, perhaps even a rival, text in the English language. We highly recommend it for classroom use in introductory and advanced-level courses on quantum mechanics.

Physical Science. Origins and Principles. By Robert T. Lagemann. 458 pp. Little, Brown and Co., Boston, 1963. $7.50.
Reviewed by ***Thomas H. Osgood****, Michigan State University.*

Courage and sensitive judgment are needed by any author who hopes to write an introductory textbook on physical science that is fully acceptable at the college level. What he does must satisfy his own standard of performance; he must capture the enthusiasm of the non-science student; he must produce something that can be taught methodically, yet learned with excitement; and he must select his material with a discrimination that borders on genius in order to dramatize the vast panorama before him. What matters in the long run, however, is not so much the pieces he chooses, as how he puts them together to give his product a logical unity. In achieving this end, Professor Lagemann has wisely built his book around the topics that were agreed upon at the Carleton Conference in 1956 as being fundamental in an elementary study of physical science, viz., conservation of momentum, conservation of mass and energy, conservation of electric charge, wave motion, fields, molecular structure of matter, and the structure of the atom.

To develop these topics and concepts in positional astronomy, he uses about 20% of the book; in classical physics, including the periodic table and simple chemical structures of molecules, about 50%; and in atomic and nuclear physics, somewhat more than 25%. Especially in astronomy and mechanics he lays stress on the historical foundations of the subject, with strong emphasis on the arguments and instruments of science since the time of Galileo. "Throughout," says the author in the Preface, "the purpose is to demonstrate—through the study of scientific laws and theories—what science is, how scientific knowledge is acquired, and how modern physical science has developed from the past. Consistent with this approach, frequent quotations from the original literature of science allow the reader to look into the mind of the scientist as he reaches a critical point in the process of discovery. Occasional allusions to contemporary figures in art and literature remind the student that science is but a part of the whole fabric of our culture." These well-chosen quotations range from Hippocrates and Ptolemy to Einstein and Rutherford.

Of mathematics, the student reader requires little beyond simple algebra, and he has his appetite whetted for subtle scientific problems by double sets of questions at the ends of all chapters. First, a set of what may be called confidence-building problems, followed by a second set requiring greater imagination and ingenuity than the direct application of a nearby formula.

The numerous line diagrams and photographs are large, clear, and intelligible; the double-column page is easy to read. The index is adequate. Attractive Lissajous figures embellish the paper jacket, but fortunately not the hard cover, for they receive no mention in the text.

On Formally Undecidable Propositions of Principia Mathematica and Related Systems. By Kurt Gödel. Transl. from German by B. Meltzer. 72 pp. Basic Books, New York, 1962. $3.00.
Reviewed by ***Richard Schlegel****, Michigan State University.*

Kurt Gödel's paper on undecidable sentences was published in the *Monatshefte für Mathematik und Physik* in 1930. Since that time his work has come to be a common topic in scientific and philosophical discussions.

A recently published general physics textbook even devotes its concluding section to Gödel and the presumed proof of the inevitably incomplete character of scientific knowledge. In view of these evidences of interest, beyond the circles of professional mathematicians and logicians, the publication of a translation of the original paper is to be welcomed, and should be helpful in dispelling misconceptions about Gödel's contribution.

And yet, it may be remarked that for most American physicists the chief barrier to comprehension of Gödel's work would probably not be one of language. The reader of the volume under review will be greatly helped by the Introduction, written by the Cambridge logician and philosopher, R. B. Braithwaite. His discussion makes up almost half of the book, and gives background material and guidance in understanding Gödel's procedure.

Gödel tells us the import of his work in the first few pages of the paper. He will establish propositions which are not decidable—propositions which can neither be proved nor disproved, if the consistency of the system is to be maintained. The system he uses is that of Russell and Whitehead's *Principia Mathematica*, and, generally speaking, Gödel's results are established for any mathematical-logical system which is "rich" enough to contain ordinary arithmetic. The undecidable proposition is, however, not one which refers to some recondite aspect of mathematics or logic; rather, it is a proposition whose content is a statement to the effect that it is not a provable proposition. At the same time, it is a formula within the axiomatic system itself, and is in fact expressible in numbers. Hermann Weyl has pointed out that, as Cantor by a mathematical technique found numbers which could not be counted, so Gödel found a mathematical way of writing statements which could neither be proved nor disproved.

What is the direct revelance for physics? It would seem that there is very little, if any at all. Suppose a Gödelian sentence were formed in, say, an axiomatic system of mechanics. The sentence would not talk about mechanical properties that had been correlated with the symbols of the

NEW for Applied Physics, Research and Teaching — over 20 low cost and truly rugged

Ealing KITS

Get the full Ealing KITS Catalog. It's free.

TWEETER-DRIVEN SOUND CHAMBER
Quantitative study of plane waves, fronts; wavelength, phase, profiles interference, diffraction, etc. (M.I.T.) **$275.00**

SMALL MASS SPECTROMETER
Resolves K^{41} and K^{39} — good team project to build and operate. Use as mass spectrometer or general vacuum system. (Dartmouth) **$235.00**

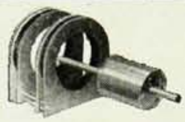
OMEGATRON: e/m OF PROTONS
New vista in study of cyclotron resonance effects and omegatron technology. (Swarthmore) **$60.00**

CLASSEN'S METHOD e/m OF ELECTRONS
This "charged particles in vacuum" Kit determines e/m to a precision of ±2%. (U. of Minn.) **$80.00**

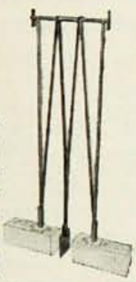
MINNESOTA IONIZATION CHAMBER
Versatility: all basic phenomena! Study Alpha, Beta, Gamma or X ionizing radiation effects on gases in small electric field. **$70.00**

NUCLEAR MAGNETIC RESONANCE ABSORPTION
Determines gyromagnetic ratio of nucleii and their magnetic moments. (Swarthmore) **$65.00**

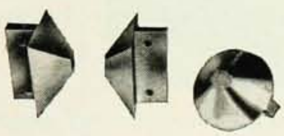
LARGE ELECTROMAGNET
A working tool, weighs 250 lbs., adjustable pole pieces 4" x 4", 10,000 gauss with ½ cm gap. Also available *Power Supply Kit.* — $125.00 (Cal. Tech.) **$350.00**



ELECTRON PARAMAGNETIC RESONANCE APPARATUS
For EPR at 315 Mc. resonance, field being obtained by using Helmoltz coils provided. (Swarthmore) **$49.50**

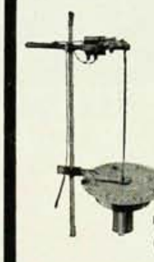


EDDY CURRENT PENDULUM
Swings wildly then stops dead in magnetic field. An accessory to the Large Electromagnet. (Cal. Tech.) **$99.50**

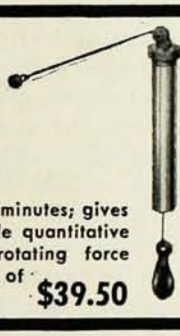


SHAPED POLE FACES
For Zeeman effect plus para- and diamagnetism with large electromagnet. (Cal. Tech.) **$65.00**

HALL EFFECT MAGNET
Compact electromagnet, coil current 2.3 amps produces field 3K gauss across 0.56 cm gap. (Purdue) **$24.75**



IMPULSE-DRIVEN TORSIONAL-MECHANICAL OSCILLATOR
Kit provides massive torsion pendulum to study transients and steady-states in resonant oscillators. (M.I.T.) **$75.00**



WHIRLYGIG CONICAL PENDULUM
Sets up in minutes; gives reproducible quantitative data on rotating force systems. (U. of Minn.) **$39.50**

AIR SUSPENSION GYROSCOPE
Steel sphere rotates on frictionless air bearing; quantitative study of pure gyro behavior. (M. I. T.) **$95.00**

EALING MINILABS
"Take-home" electronics kits at prices students can afford; carry like books. Rugged, compact, solderless "toothpick" connections. (M. I. T.)

32-501 Minilab	$12.00
32-502 Minilab	$39.50
32-503 Minilab	$69.50

Designed at leading universities, these kits put rugged equipment for modern topics into your hands at low budget prices.

THE **Ealing** CORPORATION

2227 MASSACHUSETTS AVENUE, CAMBRIDGE 40, MASSACHUSETTS system, but about its own unprovability. And, there is a further striking characteristic of a Gödelian sentence that seems to insure its physical triviality. Gödel showed that in the *metasystem* in which we talk about the undecidable sentence the sentence is indeed unprovable, as it asserts about itself, because it is undecidable; hence, in the metasystem the proposition is correct. So, as regards truth content, rather than status in an axiomatic system, the Gödelian sentence is a true one. There is, then, no irremovable undecidability. This does not at all detract from the significance of the undecidable proposition in changing our concepts of provability and completeness for mathematical systems.

We have had our own incompleteness principle in physics, since the time, a few years before 1930, when quantum mechanics was developed. There is no immediately apparent connection between the quantum uncertainty that was forced on physics by observations of nature and the undecidable sentences of certain logical systems. Still, the parallelism in development is striking, and may give a physicist added reason, in addition to its own intrinsic interest, for studying Gödel's great discovery.

Fast Neutron Physics. Part II: Experiments and Theory. J. B. Marion and J. L. Fowler, eds. Vol. 4 of Monographs and Texts in Physics and Astronomy, edited by R. E. Marshak. 2292 pp. Interscience, New York, 1963. $45.00.
Reviewed by ***H. H. Barschall,*** *University of Wisconsin.*

The first part of *Fast Neutron Physics*, which is concerned with techniques, appeared over three years ago (*Physics Today*, August 1960). The publication of the long-awaited second part completes this treatise. The two parts together form a monumental work of 2300 pages, containing forty-six chapters written by sixty-two authors. All aspects of the production and of the interactions of fast neutrons are discussed by the foremost experts in the field both from the experimental and theoretical points of view.

In the preface the editors express their regret at the delay which occurred in a number of articles between writing and publication. Some chap-