

boson systems. Thus this book is much more complete than Kirzhnits's. However, the application of these methods to atomic problems (with quite a few electrons but maybe not 238 and certainly not infinitely many) is better done in Kirzhnits's book.

In connection with finite systems, one has come again to the difficulty about $\lambda \approx 1$. Finite atomic systems are discussed in chapter 2. At the end of the chapter it is mentioned that the many-body methods developed in chapter 4 (many-body perturbation theory) hold out much promise for advances in atomic-physics calculations in the next decade. But this work is already begun, and nothing is done to guide the reader to the literature. A reference to H. P. Kelly, *Phys. Rev.* **136** B896 (1964), would have helped. Finite nuclei are not discussed at all. There are no references to Eden's and Emery's work (Sampantar's colleagues at Cambridge), or Brueckner's, Rotenberg's, and Lockett's work, or Migdal's work (based on Green functions). I suppose that these things may be excluded quite properly on the grounds that they are not altogether definitive and belong anyhow to nuclear physics rather than the many-body problem. And yet references might have been provided.

Perhaps some idea of what the book does contain as opposed to what it does not contain may be conveyed by noting that the contents remind one of the contents of the 1958 Les Houches lectures (Wiley, New York, 1959). Since the 1958 Les Houches lectures may be accepted as a satisfactory historical basis for a definition of the many-body problem, there is, in fact, a basis for the authors' claims of completeness.

As a standard test of accuracy, the reviewer uses the discussion of the Hugenholtz-Van Hove theorem. This book passes the test very well: The authors reach the correct conclusion that Brueckner's and Gammel's $V(p)$ has little in common with the potential felt by a nucleon added to nuclear matter.

Many teachers will want to consider the adoption of this book as a text. It has problems at the end of the chapters.

I like this book very much, mainly, I think, because of the contact established between the perturbation methods and Green-function methods. The authors achieve their aim

of including both methods in a single cover.

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Galileo on the Copernican system

GALILEO GALILEI: DIALOGUE CONCERNING THE TWO CHIEF WORLD SYSTEMS—PTOLEMAIC & COPERNICAN. (2nd edition) Trans. from Italian. 496 pp. U. of California Press, Berkeley, 1967. \$12.50

by David C. Lindberg

Dialogue Concerning the Two Chief World Systems is Galileo's major defense of the Copernican system. Published in 1632, it was the culmination of Galileo's long and vigorous campaign to persuade both the scholarly community and the literate public of the truth of Copernican cosmology. Written in colloquial Italian and in popular dialogue form, it embodies all of Galileo's consummate wit, sarcasm and polemical skill. The personal consequences for Galileo of its publication require little elaboration. Although the book had been officially licensed by the Congregation of the Index, Galileo was brought to trial before the Inquisition, forced to recant, and sentenced to house arrest until his death in 1642.

Nevertheless, Galileo's book must not be regarded as a narrowly Copernican or astronomical tract. Galileo conceived his task very broadly: He must deal with the full spectrum of objections to the Copernican system—metaphysical, cosmological, astronomical and physical. Indeed, one might even argue that the main thesis is physical. There is a revealing phrase put into the mouth of one of the interlocutors, Simplicio: "The crucial thing is being able to move the earth without causing a thousand inconveniences." (page 122) If not his chief aim, it was at least one of Galileo's aims to demonstrate that from the standpoint of physics it is *not* inconvenient to move the earth; that is, it was incumbent on him to formulate new physical conceptions consistent with a moving earth. Thus we find Galileo analyzing, more or less comprehensively as the occasion allows, such physical problems as centrifugal tendency, projectiles, freely falling

bodies, the motion of pendula and inertial motion. The book is therefore close to the origins of modern physics on a number of fronts, and the physicist who would learn something of the historical roots of his discipline could do worse than to read Galileo's *Dialogue*.

Nobody is better qualified to translate Galileo's works than Stillman Drake, who has also given us translations of Galileo's *Starry Messenger*, *Letters on Sunspots*, *Letter to the Grand Duchess*, *The Assayer* and *On Mechanics*. The result in this case—to waste no words—is superb. Drake's translation reflects scholarship without pedantry, a goal set by Galileo himself as revealed by a short passage quoted in the translator's preface. Drake has made Galileo speak in modern English without sacrificing the intent or flavor of the Italian original; nor is the translation ever marred by infelicities of phrasing.

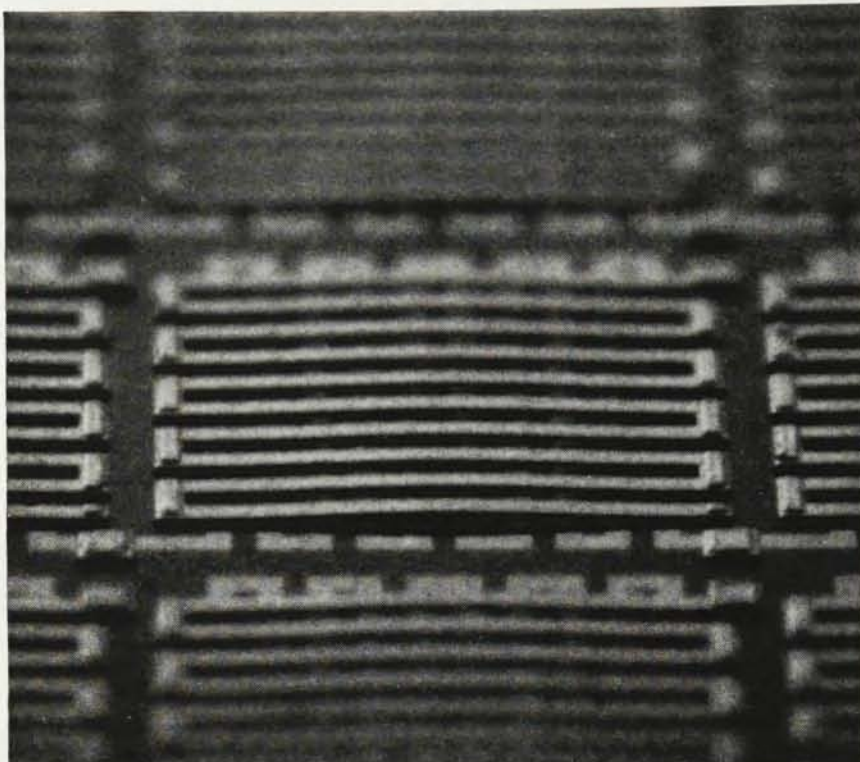
About 25 pages of notes appear at the back of the book thus providing biographical and bibliographical information and clarifying doubtful points in the interpretation of Galileo's ideas. Here (as elsewhere) Drake has revealed his unrivaled command of the facts surrounding Galileo's life and work. And yet, if there is a flaw in the book, it is in these notes. Although enthusiastically calling attention to Galileo's every anticipation of a later conception (see, for example, the notes to pages 199, 213–217, 234), the notes provide no hint of Galileo's extensive debt to his scientific forebears. The erroneous impression is too readily communicated that Galileo's scientific conceptions were formulated *de novo*. For the reader who wishes to pursue the matter, may I suggest the following works, which will provide a particularly thorough view of Galileo's debt to ancient and medieval science: Marshall Clagett, *The Science of Mechanics in the Middle Ages* (Madison, Wisconsin, 1959); Ernest A. Moody, "Galileo and Avempace: The Dynamics of the Leaning Tower Experiment," *Journal of the History of Ideas*, volume 12 (1951), pages 163–193, 375–422; Alexandre Koyré, *Études Galiléennes* (Paris, 1939); also the works of Anneliese Maier, listed in Clagett's bibliography.

Finally, since this is the second edition of Drake's translation, I must say a word about the alterations that have been made to the first edition (1953). Although the preface asserts that

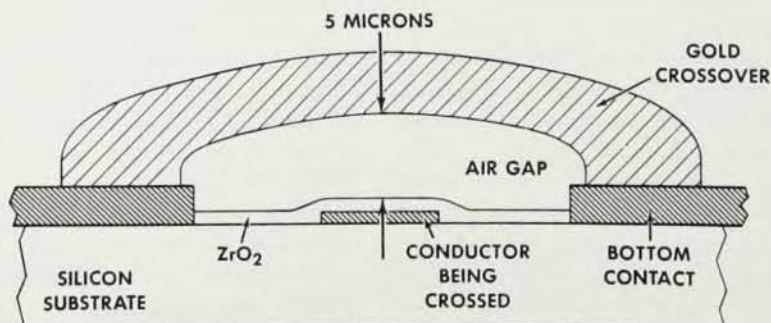
Report from

**BELL
LABORATORIES**

Microbridges for electrons



Part of an experimental test pattern. This pattern, with 13,700 microbridge crossovers on a silicon substrate, has been fabricated without a short circuit. Each of the crossovers is less than 1/16 in. long. The combination of air and solid insulation can withstand 200 volts.



Cutaway view showing formation of the new microstructure: First, layers of titanium and platinum are deposited over the substrate to form both the conductors to be crossed and the bottom contacts. A layer of zirconium is then put down. Next copper, a spacer for formation of the crossover, is evaporated overall. Windows are etched through the copper so the crossover can reach the lower-level contact. The crossover is then applied in position by gold-plating the copper spacer; the spacer is then etched away. The zirconium layer is oxidized to act as protective insulation. Any pinholes present do not become short circuits.

As integrated circuits become more complex, designers are faced with something akin to the old puzzle: "without crossing any lines or lifting your pencil from the paper, connect so-and-so-many points." In a puzzle, it's just for fun, but with circuits it has been a design requirement.

Until now, most conductors have been crossed in virtually the same plane, separated only by extremely thin insulators. Such crossovers are undesirable because of the danger of leakage through pinhole imperfections in the insulator. As integration technology evolves, hundreds of crossovers may be needed on a single substrate. A short in any one means rejection of the entire substrate. For such integrated circuits to compete economically, the integrity and manufacturing yield of crossovers must approach perfection.

Obviously, the designer would like to "lift his pencil". . . make the crossing conductor rise above the one beneath it.

Recently, Martin P. Lepselter of Bell Telephone Laboratories has done just that. He has invented a process for making "microbridges"... integrated-circuit leads which cross others through the air, without touching (photo, left).

This new technique solves the insulation problem; because of the air gap, pinholes in the insulator do not cause leakage. It also reduces capacitance between the conductors. Finally, by separating the various materials, it eliminates stresses due to unequal thermal expansion.

The key to the technique (drawing, left) is a layer of a material like copper that can be selectively etched away, leaving an air gap between the conductors. Thus the combination of air gap and insulating layer provides a degree of insulation protection not previously available. Insulated circuits with microbridge crossovers will be used in a wide variety of communications equipment in the Bell System.



Bell Telephone Laboratories
Research and Development Unit of the Bell System

changes have been made in the text, they are obviously not numerous; in fact, I have not been able to discover any of them. The notes have been altered significantly, even though the changes (once again) are not numerous. Most alterations represent minor corrections or additional bibliographical information, though on a few occasions Drake has changed his mind about an earlier interpretation of Galileo.

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Particles in the belts

RADIATION TRAPPED IN THE EARTH'S MAGNETIC FIELD. (Advanced Study Institute, Bergen, Norway, 1965) B. M. McCormac, ed. 908 pp. Gordon and Breach, New York, 1966. \$45.00

by S. Fred Singer

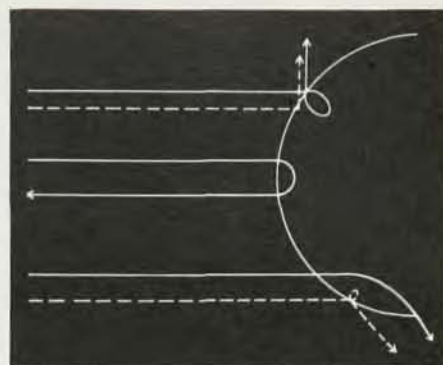
One of the dramatic findings of the initial satellite experiments was the discovery of charged particles trapped in the earth's magnetic field. The possibility of trapping and even the probability of the existence of particles had been discussed; yet the actual measurement came as a surprise to many and stimulated a vast amount of work, both experimental and theoretical. Thus, within a few weeks following the discovery and before the radiation could even be identified, one could predict with some degree of certainty the existence of high-energy protons of several hundred MeV as part of the radiation. They would necessarily be produced by cosmic rays through the intermediary of secondary (albedo) neutrons that are ejected out of the earth's atmosphere and occasionally decay in the magnetosphere, the region above the ionosphere where the geomagnetic field plays a predominant role. Even though injection rates are very low, of the order of 1 per cm^3 per million years, when multiplied by lifetime, approximately 100 years, and by velocity, about 10^9 cm/sec, one obtains the rather impressive fluxes that are measured.

One of the central problems of work on trapped radiations has been to determine whether the neutron albedo

source is indeed the major source for high-energy protons. The other central problem has been to account for the low-energy components of electrons and protons, establish their sources, their energy mechanisms (acceleration mechanisms), and their connection with the variations of the earth's magnetic field and with the aurora.

In this volume, which is based on papers presented at a NATO Advanced Study Institute, these two major problems are extensively discussed, but no completely satisfactory conclusions are reached. While the neutron albedo theory appears well established, the essential input to the theory, namely, the specification of the neutron albedo flux, its energy spectrum, angular distribution, latitude distribution, etc., is not sufficiently well known to allow a final definitive conclusion. If neutron albedo is the major source, then, for example, protons of 500 MeV energy would have to have lifetimes of several hundred years in the earth's magnetosphere. This lifetime is completely permissible from the point of view of ionization loss: But is the magnetic field steady enough to permit this excellent degree of trapping, about 10^{13} gyrations?

On the second problem, there are a great many measurements presented but, again, no final conclusion. In the organization of the institute, the related geomagnetic and auroral problems were not brought in, so the discussion could deal only with a portion of the problem. The dynamics of the magnetic field, the existence of electric fields in the magnetosphere owing to convection and similar topics were not specifically discussed. Of course these subjects are immensely complicated, and some major physical factors have not been taken into account. For example, rotation of the earth and corotation of the magnetosphere must play a role. Some slipping must take place between the corotating magnetosphere and the noncorotating interplanetary magnetic field. It appears intuitively possible to me that the rotation will result in a winding up of the lines of force until their energy density reaches some limiting value and that then a release of energy can take place through merging of the lines of force, perhaps with the solar wind acting as a triggering device. Clearly this is not an easy concept to deal with



CHARGED-PARTICLE TRAJECTORIES. This simplified model shows trajectories (solid lines positive ions, dashed lines electrons) incident perpendicular to a magnetic dipole that is projected along the equatorial plane.

analytically. On the other hand, the static models of the magnetosphere, on which a great deal of detailed discussion is here lavished, do not appear to me to be capable of explaining trapped-particle and auroral phenomena. The volume contains a good many of what I would call classical papers. Of the nearly 60 papers, many have a review character and should be useful to anyone who wishes to understand the status of the field. The rest are useful mostly for specialists in the subject.

The institute was divided into five sessions. The first dealt with B-L space, basically a description of the earth's magnetic field and the coordinate system which is useful in describing trapped-particle phenomena. The next two sessions dealt with observed particle distributions, both in the inner and outer zones, describing measurements on trapped protons and trapped electrons. Session 4 was theoretically oriented, and the participants tried to describe sources and sinks of natural trapped radiation. The neutron albedo source, the atmospheric sink and diffusion of protons of low energy appear to be the best understood phenomena. Session 5 presented a number of papers on the outer magnetosphere, including magnetospheric models and motions of charged particles in unusual magnetic environments. Session 6 described the results of measurements from artificially injected radiation during high-altitude nuclear tests. Session 7 dealt quite briefly with synchrotron radiation. Sessions 8 and 9 described effects of trapped radiation on electronic devices and on manned flight.

In reviewing the book, generally,