Anyone who even casually turns the 1200 and more pages of *Gravitation* cannot fail to be impressed by the incredible amount of effort that must have gone into its preparation. And all the greater pity because in my judgment the attempt to write three books in one is not a complete success. There is needless repetition (indeed, almost everything is stated at least three times) and the style fluctuates from precise mathematical rigor to evangelical rhetoric (which often obscures and confuses the issues). It must also be admitted (even if the distinguished authors wince at this remark) that a discriminating reader can discern where the style of one leaves off and of another takes charge. The internal evidence, in fact, suggests (?) that the burden of compiling this enormous book has been on the shoulders of one of the authors, and perhaps the repetitiveness and the amorphous character of the book could have been avoided if all three had not tried to integrate their separate but noble efforts. This repetitiveness becomes clear if one asks oneself what a student who has mastered the 150 pages devoted to general relativity in the *Classical Fields* of Landau and Lifshitz will learn from this book and how large a book will be needed to provide that additional knowledge.

One of the distinguishing marks of the book is the large amount of rhetorical prose, which invades whole sections, and there is appropriate canonization of some of the contributors to general relativity, old and young. (While selecting individuals for canonization is a matter of judgment and attitude, one wonders why neither Karl Schwarzschild nor Roy Kerr find a place in their pantheon.)

There is one overriding impression this book leaves. "It is written with the zeal of a missionary preaching to cannibals" (as J. E. Littlewood, in referring to another book, has said). But I (probably for historical reasons) have always been allergic to missionaries.

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The Quantum Theory of Light

Rodney Loudon
338 pp. Clarendon, Oxford, 1973. £7.50

Quantum optics is a relatively new and rapidly expanding field. As such, many of its more subtle aspects, such as the statistical properties of light, have not yet found their way into beginning graduate-level courses.

The present text is a milestone toward making such material available to students at this level. Rodney Loudon, a recognized authority in the field, succeeds in bringing such advanced topics as the quantum theory of laser behavior, light scattering and the photon statistical aspects of nonlinear optics to these students.

The first six chapters dealing with simple optical processes could be read with profit by senior and first-year graduate students. The next three chapters treat the quantization of the field and various optical experiments that require the quantum theory of light for their interpretation. In the latter effort, as the author points out, "the existence of the quantization leads to the possibility of a new type of experiment in which the distributions of photons in beams of light are measured. Such experiments form the observational basis of *quantum optics*." In the final third of the book, Loudon develops laser theory, light scattering and nonlinear optics in a pedagogically appealing fashion without sacrificing depth.

The only negative aspects that I came across were minor: The utility of the book as a textbook would perhaps have been enhanced with the inclusion of more problems, and secondly, the student interested in tracking down the original papers will find the bibliography a bit skimpy.

In general Loudon's text is a very fine presentation of the material and deserves a place on the shelf of every student of modern optics. In fact, my copy has already been stolen.

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Across the Frontiers

Werner Heisenberg
229 pp. Harper & Row, New York, 1974. $7.95

Werner Heisenberg is known through out the world of science as one of the creators of quantum-mechanics—both of its mathematical formalism and of its conceptual implications, and also as a man who stayed at the forefront of physics during his whole career. A collection of essays and addresses written or delivered by him during the last 15 years (only one short paper dates from 1948) is therefore certain to command the interest of many readers, and for a variety of reasons. Some may look for an authoritative description of the main lines of development of modern physics, and they will not be disappointed: in several of the chapters and especially in the one "Planck's Discovery and the Philosophical Problems of Atomic Theory," the second one in this collection, such a survey is painted with broad, yet certain strokes.

Other readers, more interested in the history of physicists than in physics and its history, may regard this book as a valuable source of information about Heisenberg himself; they will appreciate his erudition, which embodies the best traditions of German scholarship, and admire the skill with which he adapts his style to the occasion and the subject. (Compare for instance the Festival Oration for the 800th Anniversary Celebrations of the City of Munich, chapter 5, with his lecture on Abstraction in Modern Science, chapter 8.)

But the main interest of this book lies elsewhere. Through nearly all the chapters there runs a consistent philosophical attitude: Quantitative physics became only possible by a severe limitation of the range of phenomena studied. Within this limited field it has been extremely successful and it has also led to the spectacular development of modern technology. But this type of physics cannot deal with other forms of human experience that are equally important or, perhaps, more important. And science-based technology, for all its successes, holds serious threats to human society, human culture and even to human life. How-

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ever, today's atomic physics itself points to the limits of the "post-Newtonian" method—therefore it can provide useful analogies for other fields.

The book contains many striking aphorisms. Let me quote two examples. From "Changing Thought Pattern in Science" (chapter 12), "I now come back, in conclusion, to the question I posed at the beginning: 'How does one make a revolution?' And I shall assume for a moment, experimentally as it were, and without arguing with the historians, that the answer may be valid in all fields at once. It would then run: 'by trying to change as little as possible.' " And from chapter 15, "Science in the Contemporary University," we read "The dispute about specific percentages in joint decision-making strikes me as resembling the struggle of children over a toy that they have long since broken in the quarrel, and in which it can no longer matter how large a piece each of them retains."

The translation reads easily and has obviously been done with great care, but all the same I had occasionally some difficulty to understand what was meant until I translated back into German.

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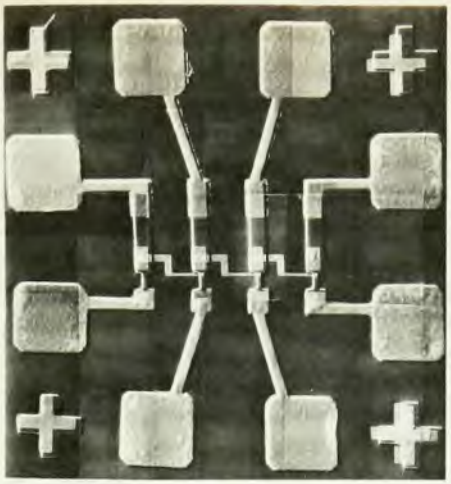
Gunn-effect Logic Devices

H. L. Hartnagel
138 pp. Elsevier, New York, 1973.
$21.00

The search for ever-faster logic processing elements has led to the application of new technologies to old devices and the application of relatively "old" devices in the logic field. This monograph by Hans Hartnagel of the University of Newcastle-upon-Tyne treats an example of the latter: the use of the traveling domains of high electric field that can exist in those semiconductors, such as GaAs, that can exhibit a bulk negative differential conductivity, to perform digital functions at high speed. Some excellent work has been done in this new field, and this volume comes at an appropriate time to serve as a useful introduction to the growing coalescence of digital and microwave semiconductor techniques.

Hartnagel is responsible for some of the earliest publications concerning the theory of two-terminal Gunn-effect logic devices and has since been involved with applications of these logic elements in communications systems. He treats in detail the major physical phenomena involved in Gunn-effect



The electron micrograph shows four Schottky-gate-triggered Gunn devices connected for pulse regeneration. Work done by K. Mause, et al. at the German Post Office.

logic elements and briefly surveys both experimentally verified and conjectural applications of these elements. Thus, the basic principles of Gunn-effect domain formation and travel are reviewed at some length, and then the implications of the planar structure of Gunn-effect logic elements on these domain dynamics are considered. The author describes the configuration, fabrication technology (very briefly) and performance of some simple logic elements and systems, such as adders and shift registers. He devotes a chapter largely to his own work on Gunn-effect digital communication systems and concludes with a chapter on some unusual and as-yet-unrealized logic applications that utilize domain formation and transit phenomena.

Unfortunately, Hartnagel does not seem fully convinced about the usefulness of three-terminal (Schottky-gate) devices, as compared to the two terminal devices. In fact, most of the work that has been done on Gunn-effect logic devices that can be seen to have some bearing on practical applications has been done on Schottky-gate devices. Thus it would have been helpful if he had included more technical and less purely descriptive material on these devices.

The author has ignored some important aspects of the systems integration of these logic devices. For example, there is no discussion of device fanout, noise margin, logic swing or interfacing with other types of logic devices. In addition, in a comparison between Gunn-effect devices and GaAs Schottky-gate FET's, the discussion of carrier velocities is unclear and does not take into account the results of Ruch and others on transient phenomena occurring in FET's.

Finally, it would have been expected that such an expensive book would have had a more complete bibliography with many more in-text references and a far more complete index. Many of the illustrations of experimental configurations and results, while understandable in themselves, refer to unreferenced work, so that a reader desiring to obtain more complete information would not be able to easily do so.

Hartnagel's book, while slightly flawed, nevertheless should serve as a useful introduction to the more general aspects of the field of Gunn-effect logic devices, with an emphasis on the major physical phenomena occurring in these devices.

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Communication with Extraterrestrial Intelligence

Carl Sagan, ed.
428 pp. MIT Press, Cambridge, Mass., 1973. $10.00

Possibly the most important interdisciplinary scientific problem under discussion today is the possible existence of extraterrestrial civilizations, and the chance that we may enter into communication with one or more of them. This book contains the proceedings of a conference held 5–11 September 1971, at the Byurakan Astrophysical Observatory of the Armenian Academy of Sciences, USSR. The conference was jointly arranged by the Academies of Science of the US and the USSR, so it is not too surprising that most of the participants came from these two countries: 32 from the USSR, 18 from the US, and only 4 from other countries. The book contains the edited transcripts of the presentations plus the accompanying discussion (which was extensive) together with a number of brief scientific notes presented as appendices.

Most attempts to quantify the probable number of intelligent civilizations in the galaxy capable of communicating with us, N, have centered around the following probability expression:

$$N = R_* f_p n_e f_l f_i f_c L$$

Here R_* is the number of stars formed per year averaged over the lifetime of the galaxy, f_p is the fraction of stars that have planetary systems, n_e is the number of planets within such planetary systems that have conditions suitable for life, f_l is the fraction of such planets on which life actually begins, f_i is the fraction of such planets on which life develops some form of intelligence, f_c is the fraction of these in which the intelligent beings develop