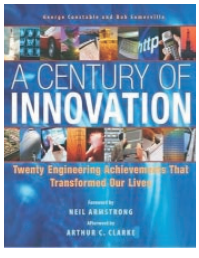
The Top 20 Countdown in 100 Years of Technology

A Century of Innovation: Twenty Engineering Achievements that Transformed Our Lives

George Constable and Bob Somerville
Joseph Henry Press, Washington, DC, 2003. $45.00 (248 pp.). ISBN 0-309-08908-5

Reviewed by John Lienhard

One should pay attention to this lovely large-format coffee-table book, for it is more than it seems to be. If you, like me, shrink from lists of the best and most important exemplars of anything—books or buildings, singers or sandwiches—then you naturally greet such an accounting with distrust. But give this book a chance.



It was developed under the auspices of the National Academy of Engineering. A number of engineering societies nominated the 20th-century technologies they felt had made the greatest positive impact on humankind. A committee then selected 20 of the technologies. Finally, two seasoned writers of technology and science actually wrote the book. They portrayed each technology with the help of many experts.

A book written by a committee can raise a cautionary flag in our minds. We therefore need to remember that, when committees function as groups of dedicated individuals, they can produce fine results. The King James Bible, the Declaration of Independence, and the US Constitution are examples. Each was produced by a committee both dedicated and contentious, and each reflects the convictions of the members. It is obvious that this book likewise has the hearts and minds of its developers written into it.

Two major questions arise immediately about the book: Is the selection of technologies a useful one? And did the authors do a good job of dealing with each technology?

One can hardly fault the selections—they are broad enough to provide remarkably complete coverage. The book's 20 chapters begin with electrification, automobiles, airplanes, and water supply, and they continue all the way through such topics as spacecraft and the internet. The technologies that gave our century its shape and form are, by and large, all present.

The organizers of the book have deftly avoided the morass that so many fall into with books of this kind—the error of trying to pinpoint specific "great" inventors and inventions. We are perfectly aware that individuals underlie each of these broad technologies. The seriously important inventors are far too numerous, and we rightly tire of hearing about a few iconographic exemplars.

In any balanced look, compromises must be struck. The Wright brothers, for example, appear in the section about flight, but so too do Otto Lilienthal, Glenn Curtiss, Hugo Junkers, Octave Chanute, and Richard Whitcomb. If Thomas Sopwith, Claude Ryan, Andrei Tupolev, and Victor Loughhead are not mentioned, the tone of the brief article is such that we can feel their presence without reading their names. If, for example, Chester Carlson and his powerfully influential process of xerography are also absent, so too must most of the great inventors go unmentioned in such an ambitious task.

The articles nonetheless convey the sense of balance and judgment that good history should provide. I was pleased to find, for example, that the article on computers avoids the hagiographical invocation of Charles Babbage and, instead, gives both George Boole and John Atanasoff their due.

Each chapter is arranged in three parts: first, a richly illustrated overview of the technological area; second, a one-page perspective statement by someone in the field; and third, a two-page timeline of milestones in the area. Bill Gates, for example, contributes the perspective piece on the computer. However, Microsoft appears in the timeline only with the 1985 introduction of *Windows 1.0*.

These three storytelling elements combine in an excellent strategy for painting a clear picture of the transformation of American life that was accomplished during the 20th century. This period (I state flatly) was the most dramatic single transformation of everyday life the world has ever seen.

That drama was particularly true of the first half of the century—the period we call "modern"—and a glance at the 20 timelines in the book reflects that fact. Most are skewed toward the years before the cold war. Indeed, the chapters on such early topics as electrification, the automobile, water supply, and the mechanization of agriculture are especially strong. That is not only because the impact of those technologies was overwhelming, but also because their history has had more time to germinate.

With the exception of the internet, all the timelines have strong roots in the early 20th century, for that was when a great explosion of inventive energy occurred; that was when our lives became unrecognizably different from those of our grandparents. That soul-stretching alteration of human existence is what this fine—this surprising—committee-built book lays before us in such dramatic terms.

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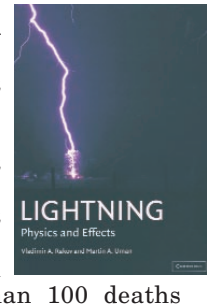
Lightning: Physics and Effects

Vladimir A. Rakov and Martin A. Uman
Cambridge U. Press, New York, 2003. $200.00 (687 pp.). ISBN 0-521-58327-6



Lightning is a gigantic spark discharge—an impressive natural phenomenon that is an object of aesthetic delight and scientific curiosity. But lightning also causes a lot of problems. It kills hundreds of people worldwide each year, with more than 100 deaths annually in the US, and it causes—

fortunately only rarely—terrible airplane accidents with dozens of fatalities. Lightning strikes result in forest fires, ignite explosives, lead to transmission line and power system failures, and disturb the operations of electronic devices that control important systems. The annual cost in the US of the power failures alone is more than $1 billion. Clearly, humankind's interest in lightning and its effects will never disappear. So the publication of a new book with a great deal of information on lightning and lightning protection is an event. *Lightning: Physics and Effects*, by Vladimir A. Rakov and Martin A. Uman, is such a book.

The modern scientific study of lightning and its effects began about 100 years ago, and the field has developed exponentially since. Scientists now have available an immense quantity of facts that need to be collected, systematized, generalized, and presented in a convenient package. Probably the first steps in this direction were taken by Uman in his book *Lightning* (McGraw-Hill, 1969). Uman's *The Lightning Discharge* (Academic Press, 1987) updated his earlier work. The new book by Rakov and Uman, who have both made numerous contributions to the field, represents the current state of the art. It has much greater topic coverage and much more information than other books on lightning, including Uman's previous two efforts. In view of the rapid pace of progress in the field, even the two-volume collection *Lightning* edited by Rudolf H. Golde (Academic Press, 1977)—a standout among serious books treating the topic—can't compete with Rakov and Uman's offering. The more than 6000 references indicate the scope and completeness of the new book. All of those references have article titles, which significantly increases the value of the reference lists.

A short review cannot possibly address every topic that is discussed in the book. Among other things, the authors cover thundercloud formation and discuss hypotheses on lightning inception inside a cloud. They also consider upward-directed lightning emitted from high grounded structures, such as towers, skyscrapers, and so forth, that lie under thunderclouds. Rakov and Uman present numerous streak photographs of lightning leaders, the faint discharges that, after they touch Earth, are followed by the main stage of a lightning discharge—the so-called return stroke. The authors offer experimental data on electric fields generated by thunderclouds and leaders as well as data on return-stroke currents. Those currents, which grow at a rate of about 10^{11} A/s and can reach an impressive 100 kA, are responsible for lightning's damages and disturbances.

The book includes a chapter devoted to triggered lightning. Such lightning is excited by a small rocket that, while flying under a thundercloud, pulls a thin grounded wire. Lightning initiates when the rocket reaches an altitude of 200–300 m. Such experiments give especially valuable information because one can prepare them with an exact knowledge of where and when the lightning will strike. That kind of foreknowledge is impossible in natural conditions.

Lightning: Physics and Effects considers the influence of lightning on electromagnetic wave propagation and on broadcasting, the hazards lightning poses to people and animals, and the generation of nitrogen oxide during thunderstorms. The book also discusses some topics, not mentioned in other books, that have recently attracted attention. Those include lightning in the middle and upper atmosphere and on other planets. Aviation specialists will find much of value on interactions of lightning with aircraft and spacecraft, and engineers will find a great amount of data on the protection of terrestrial objects.

As extensive as its coverage is, the book does leave out some things I would like to have seen. It includes very little data concerning corona ion clouds above tall structures or corona ion layers above Earth's surface: Both coronas are excited by a thundercloud's electric field. Coronas can influence whether upward-directed lightning is initiated and can effect the location of downward-directed flashes.

Lightning: Physics and Effects tells the reader what was done and by whom rather than focusing on physical phenomena. Another relatively recent book, *Lightning Physics and Lightning Protection*, by E. M. Bazelyan and me (IOP, 2000), concentrates on physical mechanisms. Rakov and Uman's encyclopedic work will be extremely useful for specialists as a rich source of factual and bibliographic information, but it won't serve as a textbook. Students and others looking for a guide to help them become acquainted with the subject should look for a book that emphasizes the physics and clearly distinguishes what we understand from what we don't.

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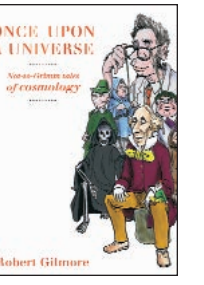
Once Upon a Universe: Not-so-Grimm Tales of Cosmology

Robert Gilmore
Copernicus Books/Springer-Verlag, New York, 2003. $25.00 (228 pp.). ISBN 0-387-95566-6

Breathes there a physicist with soul so dead,

Who never to himself has said

How can I show the public the marvels of comprehending scientific reality?



The above revision of Sir Walter Scott's 1805 patriotic verse summarizes scientists' ambitions to share the wonders they understand, and the remaining mysteries of the physical world, with those who have supported—often unknowingly—their research.

For most physicists, the desire to show the public the joys of understanding scientific reality remains unslaked—at least as far as reaching a wider audience goes. Robert Gilmore has acted upon that desire. *Once Upon a Universe: Not-so-Grimm Tales of Cosmology* is the fourth in a series of his books using fairy-tale approaches to communicate important points about physics.

In his latest book, Gilmore presents six tales. Two deal with basic physics: "The Prince and p" and "Snow White and the Particularly Little People"; two with relatively conventional astronomy: "Ali Gori and the Cave of Night" and "Cinderenda and the Death of Stars"; and two with cosmology: "Jack and the Starstalk" and "Waking Beauty." Each tale features one or more initially naive characters whose adventures bring them into contact with a wise entity—a wizard, a philosopher, a dominie, a surveyor, an artificer, or an astrogator—who explains one or more of the amazing phenomena of physics. The explanations read well, and the stories invariably end with the formerly naive character better informed.

Why then do I doubt the book's ability to secure readers among the general public? My own inclinations and experience have led to the conclusion that the public does not care for physics (or astrophysics or cosmology) packaged in the form of a fable. This disinterest is doubled when the