drawn with discretion, and contour intervals appropriate to avoid "monograph" effects have been used.

At its best, not only is an atlas useful for general orientation and a pleasure to the eye, but it puts masses of scattered information into a compact and accessible reference work the utility of which is limited only by the accuracy and scope of the available data. It can relieve researchers of much unnecessary archive work and let them get on with their main studies. The care and thoroughness with which this atlas was prepared suggest that it will fill this function to a high degree; its compilers deserve the thanks of scientists everywhere.

References and Notes

1. From the International Book. Service (V/O Mezhdunarodnaya Kniga). A few firms in the United States also maintain limited stocks of current books.
2. H. E. Hawkes, *Geotimes* **10**, 23–43 (1965).
3. Publication approved by the Director, U.S. Geological Survey.

Numbers

Francis D. Parker's **The Structure of Number Systems** (Prentice-Hall, Englewood Cliffs, N.J., 1966. 151 pp., illus. $3.95) is an excellent book. It is written with clarity, directness, and simplicity, and these are attributes we cannot take for granted. The entire contents form a single coherent story, told from start to finish. What this story is all about can best be indicated by comparing different approaches to the study of numbers.

In the first place, there is the confused approach which most of us experienced in elementary school, high school, and probably even college. We have all become accustomed to the easier ideas about numbers—we believe there is a number 4, and perhaps even a complex number like $3 + 2i$. When a number like $\sqrt{2}$ or π is concerned, we may feel a bit more doubtful.

There is a second approach, commonly used nowadays by professional mathematicians (and prominently featured in the "new math" programs for schools): one summarizes a sizable amount of information about numbers in a very succinct form, namely in the axioms dealing with commutativity, associativity, the distributive law, the existence of identity elements and inverses, axioms on order, and (ultimately) something like the Cauchy axiom on topological completeness. (I admit to a prejudice in favor of this approach as the one closest to the main concerns of contemporary mathematics.)

Now any axiom system bears some resemblance to an iceberg: there is the small amount of information which the axioms tell us clearly and explicitly, but the vast amount of information given by the axioms is not of this sort—rather, it lies beneath the surface. If our axioms are adequate, the information *implied* by them includes every single fact about our entire number system. Of course, extracting this information requires the devices of the formal logic of implications, and usually also requires considerable ingenuity and patience as well. The less our axioms say explicitly, the more they must say implicitly, and the harder it will be (in general) to carry out the necessary implications.

This brings us to our third approach to number systems. Using the axioms developed by Peano, we work with an almost unbelievably tightly knit approach: there are only five axioms. From them, using set theory and logic, we can build up all that we know about numbers, whether we think of the integers, the rational numbers, the real numbers, or the complex numbers.

Why is so much discussion of numbers worth the effort? One could claim that the answer is related to settling matters of genuine doubt about such things as infinite decimals or questions of limits, integrals, and so forth. But I think the value does not lie in this direction—indeed, set theory itself poses enough new problems and uncertainties to more than match the old problems that it may appear to settle. The real value of the Peano approach, as presented in *The Structure of Number Systems,* seems to me to lie in the tone that it takes, the point of view from which it approaches mathematical questions. Any reader whose mathematical education consisted primarily of calculus as taught two decades ago will probably see in this book a whole new way of looking at mathematics. It is an interesting viewpoint, and an important one—but perhaps it should not become the only one.

For maximum effectiveness, a book like this should probably be read before the student undertakes the study of calculus. It would make calculus take on an entirely new appearance.

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Studies of the Moon: The End of an Era

The detailed physical nature of the lunar surface has occupied the attention of astronomers for years and is now of pressing importance because manned lunar exploration is near at hand. The state of knowledge as it existed before the Surveyor landing is admirably summarized in **The Nature of the Lunar Surface**, the proceedings of the 1965 IAU–NASA Symposium (Johns Hopkins Press, Baltimore, 1966. 328 pp., illus. $13.50), edited by Wilmot N. Hess, Donald H. Menzel, and John A. O'Keefe.

The volume is organized into four parts, Interpretation of Ranger Photographs and Related Topics, Crater Formation and Surface Structure, Physics and Chemistry of the Lunar Surface, and Conclusions. Part 1 presents the various theories of the lunar surface, with strong emphasis on the Ranger photographs. The results of these papers are the most likely to be revised in the near future. Parts 2 and 3 describe the results of observational and experimental programs in which lunar luminescence, projectile cratering, optical and radar properties, physics of sputtering, lunar temperature, and the possible relationships of lunar formations to geology were investigated.

The quality of the papers is not uniform, but generally they make interesting reading. For example, there is the classical problem of the low visual albedo of the moon. Laboratory studies show that many kinds of rock powders obtain low albedos after exposure to energetic proton and alpha particles. In fact, the albedo would be less than the lunar value after prolonged exposure, and the result should be an equilibrium situation in which darkening by irradiation would be balanced by brightening due to continual exposure of undarkened material by meteoritic bombardment.

Part 4 contains a summary of the conference by E. Öpik and a substantial panel discussion. Ranger photographs are presented throughout the