try." And, he writes, his approach is "rooted in the real world," with no recourse to reduction of the time problem "to subjective concepts, such as language or psychology." These, and other comments, tell the reader that he will find no enlightenment in the book with respect to the genuine philosophical questions about the meaning and use of the time concept. Perhaps one should not cavil, for Davies has delivered well on the promise implied in the title. Yet, it is surprising: in his conclusion he rests the overall time pattern of the universe on cosmological problems which I would judge, difficult as they may be, are essentially physical; but, notwithstanding an attitude of scorn for philosophers, he in the end proposes that these last questions be left with them for solution.

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Archeoastronomy Advancing

The Place of Astronomy in the Ancient World. Proceedings of a symposium, London, Dec. 1972. F. R. HODSON, Ed. Published for the British Academy by Oxford University Press, New York, 1974. iv, 276 pp., illus. + plates. $41.75. Reprinted from *Philosophical Transactions* of the Royal Society of London, Series A, Vol. 276, No. 1257 (1974).

Science Awakening. Vol. 2, The Birth of Astronomy. BARTEL L. VAN DER WAERDEN. With contributions by Peter Huber. Noordhoff, Leyden, and Oxford University Press, New York, 1974. xvi, 348 pp., illus. $35.

Astronomy is reputedly the second oldest profession, but its origins were long ago lost in the mists of time. What was for millennia common knowledge, such as the way the ancient Egyptians mapped their fantastic animal constellations against the stars, has now been forgotten, perhaps irretrievably.

Modern scholars who would reconstruct the beginnings of astronomy have been mining the written records—from cuneiform tablets to Mayan codices—with admirable perspicacity and brilliant results. Other possible sources include those artifacts that more generally are in the province of the archeologists. Nowadays the most prominent of these are the megalithic circles that may have been prehistoric observatories.

Just over a decade ago, megalithic astronomy began to achieve international notice, somewhat to the annoyance of archeologists and of the students of "exact sciences" in antiquity. Meanwhile, the extensive measures of stone circles carried out by the indefatigable Alexander Thom have brought forth evidence that can no longer be ignored. Thus in 1972 the Royal Society and the British Academy convened a symposium on the place of astronomy in the ancient world. It is perhaps premature to say that archeoastronomy came of age with this conclave, but in the volume of proceedings the section on unwritten evidence occupies over half the pages.

Although it is the megalithic astronomy that has caught the popular fancy, this volume serves to remind us of the recent impressive progress in understanding Egyptian, Mayan, Chinese, and above all Babylonian astronomy. Many of these results are available elsewhere—Needham's material in volume 4 of his monumental *Science and Civilisation in China,* or R. A. Parker's in his monograph on the calendar of ancient Egypt plus the multivolume Neugebauer-Parker treatise, *Egyptian Astronomical Texts*—but nowhere else can one find such authoritative summaries in a single convenient place.

A. Aaboe's masterly brief review of ancient theoretical astronomy points out clearly how the Babylonian approach to planetary theory differs from Ptolemy's. J. E. S. Thompson stresses the importance of Venus in Mayan astronomy; he also expresses his doubts that the round tower at Chichen Itza served as an observatory. A. Thom's paper is an unexpected disappointment. Tersely written, it will make sense only to readers having a considerable familiarity with his earlier books and articles.

The climax of the symposium (from the point of view of the delicate balance between the "scientific" astronomy of antiquity and the more speculative interpretations of the great stone monuments) comes in the final paper, where statistician D. G. Kendall analyzes the diameters of the British stone circles to see if Thom's "megalithic yard" of 2.72 feet is a significant standard unit. Kendall's exemplary exposition makes his methods lucid even to the nonspecialist. He finds clear evidence for the megalithic yard, such that there is only a 1 percent chance that the diameters could be represented by a smooth, nonquantal distribution. Given the question "Does the analysis of the available data justify the expenditure of public monies on a costly and sophisticated aerial re-survey of the circular sites?" he answers affirmatively.

Thus megalithic numeracy has achieved a certain credibility, and Stone Age astronomy has ridden the coattails to a new respectability. Archeologist R. J. C. Atkinson, who greeted the early work with a scathing review entitled "Moonshine on Stonehenge," here cautiously points to the contradiction between "the positive evidence for prehistoric mathematics and astronomy on the one hand, and the negative evidence for recorded numeracy on the other." More recently, after further considering Thom's researches in both Britain and Brittany, Atkinson has said that he is prepared "to believe that my model of European prehistory is wrong rather than that the results presented by Thom are due to nothing but chance" (*J. Hist. Astron.* **6**, 51 [1975]).

A second important volume on ancient astronomy published in 1974 is the English translation of B. L. van der Waerden's *Anfänge der Astronomie.* A sequel to his *Science Awakening* volume on the early history of mathematics (Oxford University Press, 1961), *The Birth of Astronomy* describes Egyptian and Babylonian astronomy in substantial detail, thus furnishing the most readily accessible source for the mathematical methods of Mesopotamian astronomy.

The author's relaxed and personal style makes his book interesting to read, although English-speaking readers will be distracted by such names as "Platon," "Aristoteles," and "Apollon," an idiosyncrasy inconsistently practiced and not found in the first volume of the series. Although the typography is excellent, the 31 plates have generally been copied from halftones in the German edition rather than afresh from glossy photographs, the result being low-quality and inexcusably moiréed reproductions.

Van der Waerden's account provides a remarkable juxtaposition of the "hard" analysis of the exact sciences with "soft" speculation on the intertwining of astronomy, astrology, and astral religion. In this new version, the German original has been considerably rearranged to give greater prominence to his long chapter on cosmic religion. Briefly, he argues that the religious currents and ferment of the Middle East in the 1st millennium B.C. provided the cultural framework out of which astronomy arose. The astral aspects of the Mithraic cult and Greek Orphism furnished the background against which the zodiac became a significant astrological concept. Spurred by the collapse of the Assyrian empire in 612 B.C., these religions gained new adherents and influence; in van der Waerden's view, the fact that systematic planetary observations begin at about this same time is not accidental. In turn, the rapid development of computational methods made horoscopic astrology a possibility for the first time. Incorporated into Zoroastrianism, astrology provided a vehicle for the spread of Babylonian mathematical procedures first into Greece and later into India and Hellenistic Egypt.

Such fascinating conjectures found no place in the London symposium, nor were several other areas of speculative prehistoric astronomy so much as mentioned: W. Hartner's idea that zodiacal motifs pervade the decorative arts of ancient Mesopotamia; H. von Dechend and G. de Santillana's claim that mythology records a preliterate knowledge of the precession of the equinoxes; or A. Marshack's belief that certain Ice Age artifacts chronicle an early lunar calendar. Unlike the megalithic yard, these suggestions cannot be put to a mathematical test, and the symposium was perhaps justified in excluding them. Nevertheless, as Mark Twain remarked in another connection, such speculations are "interesting if true, and interesting anyway."

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Transformations and Their Generalizations

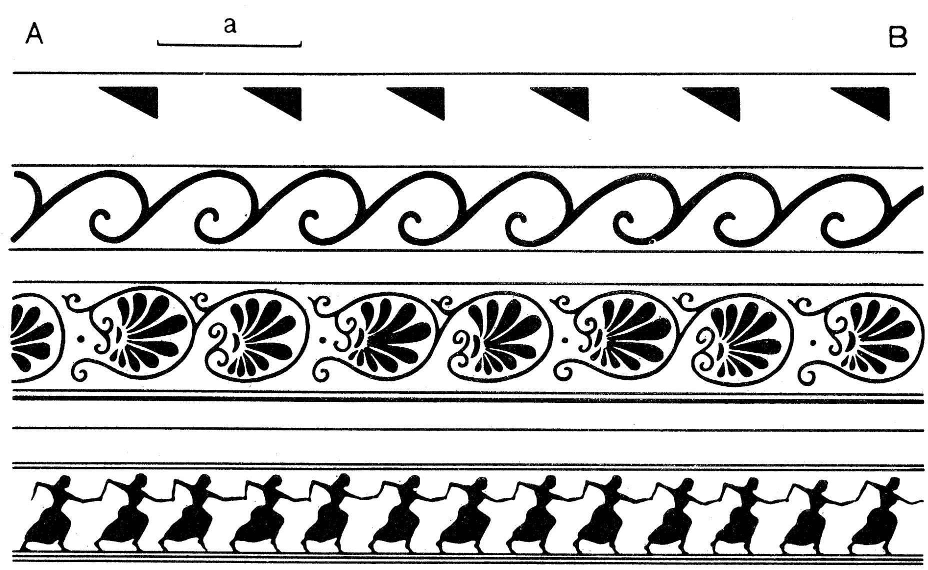
Symmetry in Science and Art. A. V. SHUBNIKOV and V. A. KOPTSIK. Translated from the Russian edition (Moscow, 1972) by G. D. Archard. David Harker, Transl. Ed. Plenum, New York, 1974. xxvi, 420 pp. + plates. $35.

This is an extraordinary book, dealing with symmetry in all its aspects and written for the nonspecialist as well as the specialist (crystallographer and physicist) in this domain of natural sciences. It is composed of 12 chapters. It starts with the symmetry of figures with a singular point in two and three dimensions (rosettes, blossoms of plants, and other biological objects, crystals, vectors, tensors)—crystallographic and noncrystallographic point groups. Then translations are introduced: in one direction (symmetry of one- and two-sided bands and of rods), in two directions (network and layer patterns, including two-dimensional continua and semicontinua), and in three directions (symmetry of spaces, especially space groups and discontinua and continua). More recent developments in symmetry theory are covered in the remaining three chapters, which are written by Koptsik alone. These developments include the theory of the extension of groups (by means of direct and semidirect products and quasi-products)—that is, the derivation of new groups from original ones—as applied to classical (Fedorov), antisymmetry (two-colored, Shubnikov), and colored-symmetry (Belov) space groups; the derivation of limiting groups of colored symmetry; and combination of the dissymmetrization and the symmetrization principles to form a single symmetry principle for composite systems.

As to the definition of symmetry, the principle given in Hermann Weyl's classic *Symmetry* (1952) is the most general: "Whenever you have to do with a structure-endowed entity . . . try to determine its group of automorphisms, the group of those element-wise transformations which leave all structural relations undisturbed."

Two small biographical corrections may be inserted at this point: Weber was a Swiss, not (as is implied on p. 189) a German, crystallographer, and Emmy Nöther certainly was not (as she is called on p. 341) "Klein's successor," except perhaps in a quite general sense, as a member of the Göttingen school headed by Hilbert and Weyl.

In the book many examples from the kingdom of art are given. This is treated in the last chapter, which was of special interest to the reviewer because he has given several lectures and courses on "symmetry in nature and art" at the University of Bern and at the C. G. Jung-Institute in Zürich (see "Symmetrie und Form," *Mitt. Naturforsch. Ges. Bern* **1940/41**, 5; "Die Idee einer Struktur der Wirklichkeit," *ibid.* [N.F.] **14**, 141 [1957], translated in *Main Curr. Mod. Thought* **26**, 67 [1970]). It is quite clear that the concept of symmetry is of general philosophical importance in the field of *Erkenntnistheorie*, and the reviewer has detected certain analogies between elements of symmetry and archetypes, both being conceptual or formal factors assembling the material and the psychic, respectively, in a meaningful, regular way. They form, in a general sense, a group. The symmetry elements, like the archetypes, are abstract and intangible, and first become manifest when they are charged with a definite content. This can



One-sided bands with one translation axis. "We must remember . . . that the concept of 'band,' like that of 'rosette' . . . is used as a . . . scientific term rather than in the everyday sense . . . Let us consider an infinite series of equal figures, plane or three-dimensional, disposed relative to one another as indicated [above]. If the whole row . . . is moved through a distance *a* along the straight line *AB* . . . so that one of the figures coincides with its neighbor, the whole set of figures will assume a new position differing in no way from the original. The straight line *AB* is called the *translation axis* . . . Since displacement by a distance *a* does not introduce any changes, it may be repeated as many times as desired. The displacement . . . may take place in the direction *AB* or in the reverse direction *BA* with the same result. Since it is not the actual line *AB* but its orientation in space which is of importance . . . any straight line parallel to *AB* can be taken as the translation axis. The set of all parallel translations creates a new symmetry class, a translation group for our infinite figure. The shortest distance *a* through which the row of figures can be translated and still come into coincidence with itself is called the *elementary translation* or *period*. The translation axis, denoted by the same letter *a*, is a symmetry element encountered only in infinite figures . . . The type of one-sided bands described here is often encountered in applied art and architecture, and may be particularly recommended [where] it is desired to . . . emphasize forward motion, e.g., in the decoration of underground subway passages and intersections intended to produce a flow of people in one direction." [From *Symmetry in Science and Art*]