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(*b*. Nuremberg, Germany, 14 February 1468; *d*. Nuremberg, May [?] 1522), *astronomy, mathematics, geography*.

While still a student in Nuremberg, Werner was drawn to the exact sciences and later said that he was intended for the study of mathematics from his early childhood. He enrolled at the University of Ingolstadt on 21 September 1484; and in 1490 he was appointed chaplain in Herzogenaurach. While studying in Rome (1493-1497) Werner was ordained a priest and met Italian scholars. By then his knowledge of mathematics, astronomy, and geography had increased; and he was allowed to inspect scientific manuscripts. He owned a Menelaus manuscript and was acquainted with unpublished works by jābir ibn Aflah (Geber) and Theodosius. Werner probably acquired his excellent knowledge of Greek in Italy. After his return to Nuremberg he celebrated his first mass in the church of St. Sebald on 29 April 1498. Probably in response to the requests of Empress Bianca Maria, in 1503 he was appointed priest at Wöhrd, just outside Nuremberg. In 1508 he was serving at St. Johannis Church in Nuremberg, where he remained until his death (between 12 March and 11 June 1522).

Werner was reputed to have been "very diligent" in carrying out all official responsibilities. Since his pastoral duties were rather limited, he devoted much of his time to scientific study. His works brought him recognition from such Nuremberg scholars as Willibald Pirkheimer (1470-1530), Sebald Schreyer (1446-1520), and Cardinal Matthäa us Lang (1468-1540). He was friendly with Bernhard Walther (*ca*. 1430-1504) and the choirmaster Lorenz Beheim (1457[?]– 1521) from Bamberg, as well as Albrecht Düreer, who occasionally asked his advice on mathematical problems. Werner enjoyed an excellent reputation even among scholars from Vienna: in 1514 the mathematician and imperial historiographer Johannes Stabius arranged the publication of a collection of writings on geography that included works by Werner. The humanist Konrad Celtis, whom Werner regarded as his "most beloved teacher," tried in 1503 to have Werner transferred to Vienna. Emperor Maximilian I appointed him chaplain at his court.

Not all of Werner's numerous works were published during his lifetime. Some remain unprinted, and others have been lost. Besides the 1514 collection containing Werner's and other authors' writings on geography,a collection of mathematical and astronomical works was published at Nuremberg in 1522. A handwritten remark in the Munich copy of the latter work leads us to believe that Werner died while the work was being printed. His meteorological treatise appeared after his death, and his works on spherical trigonometry and meteoroscopes were not published until 1907 and 1913, respectively.

Astronomy. In a sense Werner can be regarded as a student of Regiomontanus, for he had access to the latter's writings. Although a skilled maker of astronomical instruments, he showed less talent in theoretical work. The Germanisches Nationalmuseum in Nuremberg possesses a gold-plated brass astrolabe from 1516, probably made by Werner (see Zinner, pl. 25, 4). the clock on the south side of the parish church in Herzogenaurach and the two sundials in the choir of the church at Rosstal may be by Werner. He improved the Jacob's staff that had been used by Regiomontanus to measure interstellar distances, and he described it in the 1514 collection ("In eundem primum librum…Ptholomaei…" ch. 4, annotations 3–5).

Werner also invented an instrument that he called a "meteoroscope" to solve problems in spherical astronomy. It consists of a metal disk divided into quadrants with a pointer attached. Like the saphea, the first and fourth quadrants contain a stereographic projection of the circles of latitude and longitude, while the second and third quadrants have two different types of sine divisions. The device, which is only known from the description in "De meteoroscopiis," was built not for observational purposes but to replace as many mathematical tables as possible. Even here Werner proved to be a student of Regiomontanus, although his meteoroscope had nothing in common with the device of the same name built by his famous predecessor: Regiomontanus' instrument, the directions for use of which were published by Werner, is an armillary sphere. Werner's treatises on sundials and on astronomical and geographical problems that can be solved by methods of spherical trigonometry have been lost.

A manuscript dated 1521 concerning the making of a device designed to determine the latitudes of planets and one containing tables for the five planets are among Werner's unpublished works, as is a letter to Sebald Schreyer about the comet of 1500. Several horoscopes give evidence of Werner's work in astrology. They were cast for Ursula Gundelfinger, Erasmus Topler, Willibald Pirkheimer, Christoph Scheurl, and Sebald Schreyer.

Werner had less success with his treatises on the movement of the eighth sphere, which constitute the last section of the collection of works published in 1522. He maintains that the so-called precession of the stars would be an irregular movement, thus showing that he was a disciple of the Arab trepidation theory. In a letter to the canon of Cracow cathedral, Bernhard Wapowski. Copernicus attacked the treatise vigorously; and Tycho Brahe criticized it by accusing Werner of having failed to observe accurately enough the three stars that Werner took as the basis of the movement of the eighth sphere.

Mathematics. Werner's mathematical works are in spherical trigonometry and the theory of conic sections. His principal work on spherical triangles was printed in 1907 from the copy in Codex Vaticanus Reginensis Latinus 1259 (fols. lr–184r). A second copy of the autograph that contains figures was later discovered by Ernst Zinner (Landesbibliothek Weimar, no. f 324, fols. **1** – 103). Rheticus intended to publish the two writings, but only the letter of dedication to Ferdinard I of Bohemia and Hungary appeared (Cracow, 1557). The work, in four parts, which was written between 1505 and 1513, was not revised for publication by Werner. A fifth part for which he collected material has been lost. Although the treatise is incomplete, Werner's work was the best of its kind at the time, and its presentation surpassed that in Regiomontanus' books on triangles. In comparison with Regiomontanus' treatise, Werner's work is notable for its methodical presentation and practical applicability.

The various types of triangles are systematically described in part I. The following parts, which probably were written earlier, contain a theory of triangular calculation suitable for practical purposes. The basic formulas of spherical trigonometry and instructions for the solution of right spherical triangles are given in part II, and parts III and IV concern the calculation of oblique-angled triangles. In part IV Werner uses formulas that correspond to the cosine formula. Thus in proposition he does not use the cosine formula as it is known today.

$\cos b = \cos a \cos c + \sin a \sin c \cos B$

(angle B is sought; *a, b, c* are the sides), but writes

This means that Werner implicitly used the formula

$2 \sin a \sin c = \cos (a - c) - \cos (a + c)$,

whereby he could replace multiplication and division with addition and subtraction. This method, which later became known as prosthaphaeresis, was first used by Werner, but mathematicians soon realized that it simplified calculation. Perhaps through Rheticus, Tycho Brahe learned of this procedure, which was used until the introduction of logarithms.

The treatise containing twenty-two theorems on conic sections was intended as an introduction to his work on duplication of the cube, For that reason Werner dealt only with the parabola and hyperbola but not with the ellipse. In a manner similar to the methods of Apollonius, Werner produced a cone by passing through the points of the circumference straight lines that also pass through a point not in the plane of the circle. In contrast to the ancients he did not consider the parabola and the hyperbola to be defined as plane curves but regarded them in connection with the cone by which they were. formed. He proved the theorems on conic sections through geometrical observations on the cone.

Werner's report on duplication of the cube contained nothing new, being only a revision of the eleven solutions to this problem found in classical antiquity; they were known to Werner from the translation of the commentary by Eutocius on Archimedes prepared by Giorgio Valla. Werner added twelve supplementary notes to his treatise. The first ten dealt with the transformation of parallelepipeds and cylinders. In the eleventh note Werner proved that the sun's rays fall on the earth in parallel, and in the twelfth he showed that the rays are gathered in one point on a parabolic mirror.

The third writing in the collection of works dated 1522 also contained an Archimedean problem already treated by Eutocius, in which a sphere is to be cut by a plane so that the volumes of the two spherical sections are in a given proportion to each other (*De sphaera et cylindro***II** , 4). Werner added his own solution, in which a parabola and hyperbola intersect each other, to those of Dionysodorus and Diocles.

Some mathematical works by Werner have been lost, including one on arithmetic, a work that apparently was influenced by Euclid's *Data*, and a translation of Euclid's *Elements* into German that Werner completed at the request of Pirkheimer and Sebald Beheim for the sum of 100 taler.

Geography and Meteorology. The collection dated 1514 contains Werner's works on mathematical geography. In the commentary on the first book of Ptolemy's *Geography*, Werner explains the basic concepts of spherical geography and then turns to the measurement of degrees on the sphere. When determining the declination of the sun, he refers to the tables compiled by Georg von Peuerbach and Domenico Maria. Werner's method is interesting in that it determines simultaneously the longitude and the latitude of a place (ch. 3, annotation 8): For the first time it was possible for two sites the locations of which are being sought to be found by a combined series of observations. Since for the determination of latitude it is necessary merely to observe the upper and lower culmination of a circumpolar star, but not the position of the sun, quite a few sources of errors were removed. The fourth chapter deals with the determination of the difference in longitude of two places, which can be obtained by simultaneous observation of a lunareclipse. Another method is based in the determination of the distance of a zodiac star from the moon as seen from two places (ch. 4, annotation 8). This method of calculating the distances to the moon requires only the determination of the angular distances, which can be carried out by means of the Jacob's staff, and the precise knowledge of the true and mean motions of the moon. This method soon replaced the older ones and was then used as the principal method for determining longitude in nautical astronomy.

The methods used by Werner enabled him to improve or to explain certain details of the ancient geographers, especially those of Marinus. Warner's remarks in chapters 7–10 refer to Marinus' determination of places, which he proves to be often incorrect, or to the sea voyages mentioned and explained by Marinus. Werner demonstrated a knowledge of the existence and direction of the trade winds and explained their origin. In addition, he tried to present a theoretical proof of approximate formulas for the determination of distances that were used in navigation.

Warner's contributions to cartography are based on his criticism of Marinus: they can be found at the end of the commentary on Ptolemy and in the "Libellus quatuor terrarum orbis …" The remarks on chapter 24 of the *Geography* lead us to believe that Werner understood the two projections used by Ptolemy (simple conic projection and modified spherical projection) and developed them. The treatise on four other projections of the terrestrial globe, which is dedicated to Pirkheimer, contains more new ideas. In it Werner outlines the principles of stereographic projection and emphasizes that any point on the surface of the sphere can be chosen as the center of projection. In addition. Werner develops three cordiform map projections that resemble one another; the second gives an equal-area projection of the sphere. The idea of an equivalent projection occurred earlier in the works of Bernard Sylvanus, but Werner and Johannes Stabius were the first to work it out mathematically. Later, Oronce Fine, Peter Apian, and Gerardus Mercator adopted the cordiform projection. It is not known whether Werner designed a map of the world.

Werner's work in geography gained widespread recognition. Peter Apian, in particular, was a student of Werner's in theoretical cartography. The treatises contained in the collection dated 1514 were included almost unchanged in Apian's *Introductio geographica* (1533); Apian even used the proof sheets from the beginning of "In eundem primum librum…argumenta" to the end of "Joannis de Regiomonte epistola…de compositione et usu cuiusdam meteoroscopii," and admits in several places in his writings how much he had learned from Werner.

In meteorology Werner paved the way for a scientific interpretation. Meteorology and astrology were connected, but he nevertheless attempted to explain this science rationally. A short text on weather forecasting is still available in the manuscript "Regula aurea…" The "guidelines that explain the principles and observations of the changes in the atmosphere," published in 1546 by Johann Schöner, contain meteorological notes for 1513-1520. The weather observations are based mainly on stellar constellations, and hence the course of the moon is of less importance, Although Werner did not collect the data systematically, as Tycho Brahe did, he attempted to incorporate meteorology into physics and to take into consideration the geographical situation of the observational site. Thus he can be regarded as a pioneer of modern meteorology and weather forecasting.

Other Works. The manuscript Codex Guelf. 17.6 Aug. 4° (Herzog-August Bibliothek, Wolfenbüttel) is an autograph in which words occasionally are crossed out and numerous addenda appear in the margin. The treatise gives an annallike presentation of important events that occurred in Nuremberg between 1506 and 1521, most of which were political. On folios 41v and 70v two astronomical drawings that refer to Nuremberg are incorporated into the text.

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Menso Folkerts