DISCUSSION AND CORRESPONDENCE

BABYLONIAN DISCOVERY OF THE PRECESSION OF THE EQUINOXES

RECENTLY it has been shown[1] that the slow motion of the equinoctial points on the ecliptic, called the precession of the equinoxes, was first discovered before the time of Hipparchus, by a Babylonian astronomer *Kidinnu* (sometimes written *Kidenas* or *Cidenas*), who directed an astronomical school at Sippra, on the Euphrates, about 343 B. C. This Babylonian achievement had been suspected for some years, but no definite conclusion had been reached, because of uncertainties relating to the interpretation of astronomical records.[2] The final settlement of this question has become possible by the examination of some new Babylonian tables.

The fact that the astronomer *Naburiannu* (about 508 B. C.) fixed the equinoctial point at 10°, and Kidinnu, about a century and a half later, at 8°, the zero point on the ecliptic being interpreted as the same in both cases, shows that Kidinnu had a knowledge of the precession of the equinoxes. A study of tables indicates that from that time on, in the ephemerides following the system of Kidinnu, the zero point on the ecliptic was shifted from time to time, to enable astronomers to retain the same angular value for the beginning of the autumnal equinoctial years. This again implies a knowledge of precession. A table (VAT 7821) prepared not later than 186 B. C., and based on the Kidinnu system, gives solar longitudes from day to day, differing by 59′9″, an amount in excess of the true average value of 59′8″9‴.6 for a sidereal year, which was estimated by Kidinnu to be $365^{d}6^{h}13^{m}43^{s}$. This excess was corrected in the table by taking on a certain day 56′9″ in place of 59′9″. Thus the computer of the table took the average daily velocity of 59′9″ to yield in the course of one year, not exactly 360°, but an additional 3′. Dividing 360°3′ by 59′9″, and allowing liberally for certain possible sources of error, Schnabel concludes that the year considered by the computer could not have exceeded $365^{d}5^{h}30^{m}$. The modern value for the equinoctial solar year is $365°5^{h}48^{m}45^{s}$. Thus the Kidinnu astronomy had two years, the sidereal and the equinoctial. Kidinnu deserves to be ranked among the greatest astronomers of ancient times.

FLORIAN CAJORI
UNIVERSITY OF CALIFORNIA

[1] Paul Schnabel, "Kidenas, Hipparch und die Entdeckung der Präzession," *Zeitschrift für Assyriologie*, N.S., Vol. 3, April, 1926, p. 1–60.

[2] F. X. Kugler, "Sternkunde und Sterndienst in Babel," II Buch, II Teil, 2 Heft, 1924, Anhang II.

PUBLICATION BY PHOTOGRAPHY

IN connection with Professor Albrecht's article in SCIENCE for December 31, 1926, on "Publication by Photographic Reproduction of Typewriting," it should be noted that the Coast and Geodetic Survey has been using a similar method for some of its publications since 1923.

Attention was called to the possibility of using such a method by a publication of the Topographic Surveys Branch of the Department of the Interior of Canada, "Magnetic Observations in Western Canada," which appeared in 1921. In it the tabular matter, about 270 pages, was all reproduced photographically from typewritten sheets.

The advantages of such a method were recognized at once, not only the great saving in cost, but also the elimination of the tedious operation of proofreading a mass of figures and the inherent danger of errors being overlooked even by experienced readers, and steps were taken to make use of it where possible. The publications giving the results of observations at the magnetic observatories of the bureau consist largely of tables of uniform size and are, therefore, well adapted to photographic reproduction, and the method was given its first trial with them.

The principal tables give for each hour of each day of the year the values of declination, horizontal intensity and vertical intensity, as well as daily maximum and minimum values and daily and monthly means. These quantities are tabulated by months on suitable forms by means of a specially designed cross tabulating machine, the tabulation being made as the quantities are computed. A carbon copy is made at the same time, and this serves as the copy for photographic reproduction, after such changes have been made as result from the revision of the computation. With care in using fresh carbon paper there is no difficulty in securing a good reproduction even when the reduction in size is considerable.

The method is being used successfully in the publication of the quarterly Seismological Reports of the bureau, the issue of which began in 1926. In this case the copy for reproduction is prepared by typewriter, either with or without carbon paper backing.

D. L. HAZARD
COAST AND GEODETIC SURVEY,
WASHINGTON, D. C.

REFERRING to the letter by Dr. Albrecht regarding the advantages of photographic reproduction in publishing, I should like to add my testimony to the excellence of the method for all uses, but especially for tabular matter. The American Jersey Cattle Club has for several years been publishing its tables of production by the animals of the breed it records by this method, and the results are really not inferior to