THE BULLETIN OF THE HYDROGRAPHIC DEPARTMENT, IMPERIAL JAPANESE NAVY, VOL. III: PREPARATIVE TABLE OF TIME DETERMINATION BY METHOD OF EQUAL ALTITUDES OF DIFFERENT STARS

M. KAMENSKY

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HYDROGRAPHIC DEPARTMENT,
IMPERIAL JAPANESE NAVY.

VOLUME III.

Preparative Table of Time Determination by Method of Equal Altitudes
of Different Stars, for the North Latitudes 20°-40°
and for the Epoch 1930.0.

Carried out by the Order of the Hydrographic Department.

By M. KAMENSKY,
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Tokyo, 1922.

PREFACE.

The present volume contains the preparative table of time determination by the method of equal altitudes of different stars available for the north latitudes 20°–40°, for which we have had no such example.

This work was elaborately accomplished with wonderful rapidity by the Russian astronomer, M. Kamensky, former Director of the Vladivostock Naval Observatory, under the supervision of T. Nakano, Naval Engineer.

This bulletin was issued hitherto under the English title "The Bulletin of the Hydrographical Office." But from the present volume it is changed to "The Bulletin of the Hydrographic Department," it is merely because the English title of this department has been instructed to be so read.
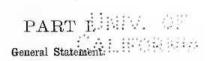
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S. INUZUKA, REAR-ADMIRAL.

Hydrographer, Imperial Japanese Navy.

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Tokyo, December, 1921.

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PART I.

General Statement.

§ 1. A Short Historical Summary of the Past Works.

The method of time determination by observing two different stars at equal altitudes, was first brought into practice by the Russian astronomer and geodetist, Prof. N. Zinger. His work in this line is so complete both in theory and in practice, that any further developement is hardly needed. Being proposed first in 1780 by Koehler, an astronomer in Dresden, this method remained without practical application during a century. Indeed many great investigators such as Tammerlander, Olbers, Hennert, Gauss, Delambre, Knorre, took up the subject; but their works were limited to the theoretical parts. They never established any practical procedures by which we can select the pairs of stars, and by which the superiority of the method in question to the others can practically be evidenced.

It is from this circumstance that, extremely simple and precise as it is, the actual application of this method remained unnoticed for a whole century. In 1874, Prof. N. Zinger first pointed out that this method, when executed with star-pairs properly selected, is far superior to many others, and it was practually shown that this method enables us to determine the time in only about 10 to 12 minutes, with an error not surpassing a small fraction of a second.

From this fact this method came to replace the two methods of time observation existing at that time, i. e. that with a transit instrument in meridian, and that with a vertical circle of Repsold. Prof. Zinger's method was especially found to be the most convenient in astronomical expeditions for the purpose of determining longitudes and latitudes, because it demands only a comparatively small universal instrument, merely provided that it is furnished with a sensible level parallel to the vertical circle.

Prof. N. Zinger, in his work: „ Die Zeitbestimmung aus correspondirend-en Höhen verschiedener Sterne, 1874," thoroughly studied this method

both theoretically and practically, and gave a list of 160 star-pairs, consisting of the brightest stars, and well distributed over the whole sidereal day, by which the time observation is enabled to be readily accomplished in any north latitude from 30° to 70°. Numerous examples given in this remarkable work, suggest that this method is much preferable to others.

The works which subsequently appeared added to the above comparatively little, the principal improvements by them being only some increase of the number of star-pairs and some facilitations of the computation of the star list. Thus Kortazzi, in his work: „Hülfstafeln zur Berechnung örtlicher Ephemeriden für die Zeitbestimmungen nach der Zinger'schen Methode, 1891,“ increased the number of star-pairs to 186, and distributed them a little more conveniently than Prof. N. Zinger did in his work. The general arrangement of Kortazzi's table is the same as that of Zinger's table. T. wittram, in his work: „Tables auxiliaraires pour la détermination de l'heure par des hauteurs correspondantes des différents étoiles, 1892,“ increased the number of star-pairs to 200, and published a few auxiliary tables, with which one can rapidly and conveniently prepare the elements for the observation in any north latitude from 30° to 70°. The tables of Kortazzi and of Wittram are computed with the star-coordinates referred to 1900.0.

But in order to bring the method of Prof. N. Zinger into general use in astronomical expeditions and in geodetic surveys, it was found to be extremely desirable to simplify the formation of the preparative data to such a degree, that an observer need not spend much time for the computations of the moments, the zenith distances and the azimuths of the stars at the time of observation. For this purpose, Colonel Stchetkin of the General Staff, calculated, making use of T. Wittram's auxiliary tables, such preparative data for the Wittram's 200 star-pairs and for every two degrees of the north latitudes from 40° to 60°.

Stchetkin's table depend upon the star-places for the epoch 1900.0, and contains the moment (in local sidereal time) of equal altitudes of the two stars of each pair, their common zenith distance and their individual azimuths, when the two stars are to be observed at equal altitudes with an interval 5 minutes of time, the east star being first observed. The table also contains

the variations of the zenith distance and of azimuths in 5 minutes of time. These variations enable us to find by simple additions the corresponding data required in observing the two stars likewise, but the west star being first observed. It contains at the same time the variations of the zenith distance and of the azimuths with respect to latitude, by which we can easily reduce the above cited data to any north latitude within the limits 40° and 60°.

Stchetkin's table was published by the Military-Scientific Committee of the Chief Military Staff in St. Petersbourg in 1902, with the title: „ Эфемериды звѣздъ для опредѣленія времени по способу Проф. Цингера." This extensive volume contains 572 pages.

Stchetkin's table was extended to the north latitude 70° by Mr. Dolgoff, the astronomer of the Emigration Office of the Russian Department of Agriculture.

All the tables hitherto mentioned, however, are only for latitudes higher than 40° and they do not give the limit of the difference of the declinations of the two stars to be brought into a pair, nor the admissible limits of their azimuths and of their zenith distance. This vacancy was filled by „ Handbuch für Küstenvermessungen" published by the German Department of Navy, in Berlin, 1906.

This work contains a table of auxiliary quantities to facilitate the computations of the zenith distances and the azimuths of 351 star-pairs (Tafel 1a). It is available for all the latitudes from −90° to +90°. It is formed on a schema which has some likeness with Wittram's tables; but it is less accurate, and above all less convenient than the latter, the computations thereby to be performed being more complicated and demanding more time. The same German work further contains a list of more 528 star-pairs (Tafel 1b), for which however the auxiliary quantities as above mentioned are not given.

These two tables are given for the epoch 1910.0, and the star-pairs are selected in such a manner, that the declinations of the two stars forming a pair do not differ by more than 1° 10′, the zenith distances are always within the limits 20° and 70°, and the azimuths do not deviate from the prime vertical more than 40°.

§ 2. Some Peculiarities of the Present Work.

The present work is a continuation of the tables hitherto mentioned, extended to some lower latitudes, viz., from 20° to 40°. It contains a table of data of 200 star-pairs such that the observer needs make no computation except some mental arithmetic operations, which may be accomplished at the very moment of setting his instrument for the observation of a star-pair.

The arrangement of materials in the present work is quite different from those in the foregoing works. This difference enabled us to shorten considerably the extent of the table reducing it from 572 pages (in Stchetkin's table) to only 200 pages. Moreover the present table, being given for every complete degree of latitude, facilitates considerably the very use of it, and above all greatly preserves us from all possible mistakes during the mental interpolations.

It was our utmost endeavor to bring the declinations of the two stars of each pairs as near as possible, to observe them in azimuth not deviating much from the prime vertical, and to limit their zenith distances between 20° and 70°. For the purpose of controlling we further intended to make use of all those pairs of Wittram's table, which satisfy the conditions just mentioned for the epoch 1930.0, and to use all those pairs in „ Handbuch für Küstenvermessungen " which are available for our purpose.

To meet these requirements, the number of stars was augmented to 171 from only 99 in Wittram's and Stchetkin's tables. The catalogue of these 171 stars are given in Part II.

The star-pairs given in Parts III and IV are selected in such a manner that the following conditions always exist for any north latitude from 20° to 40°, and for the epoch 1930.0 :

$$-35' \; < \epsilon < + 35'$$
$$20° \; < z < \; 70°$$
$$230° \; < A_E < \; 310°$$
$$50° \; < A_W < \; 130°$$

These conditions enable us to simplify the formulas for computing the correction of the chronometer from an actual observation of a star-pair, as it will be shown afterwards.