tables. He had, by this time, drawn up tables, and they were almost ready for publication. The author had evidently given more thought to his previous opinion of the useful range of the tables. He informs us that his earlier opinion—in which he stated that reliable results could be expected for a range of 30–40 minutes of hour angle on each side of the P.V.—took into account only the first two terms in the series connecting changes of zenith distance and hour angle. Although the second term in this series vanishes when Z is 90°, the third term, which includes d^3z/dh^3, does not vanish. The third term reduces to $-1/6 \sin^2 1' \sin c \cos^2 c \, (15t)^3$ where c is the co-latitude and t the approximate interval in minutes of time before or after passage of the P.V. Taking this expression into account, a correction in seconds to be applied to the hour angle, as found from the observed zenith distance, may easily be tabulated. With this correction table Goodwin pointed out that the range of the table is practically doubled.

Goodwin's *Position Line Star Tables*, published by Potter at 5/-, appeared before the close of 1906. The tables, of about 110 pages, provide the navigator with the means of fixing his ship by reduction to the meridian and to the prime vertical, without logarithmic computation. It is equally adapted to both the intercept and the 'longitude' methods.

Comparison of the investigations made by Mr. H. B. Goodwin, R.N., and Dr. Cunningham into the very interesting problem of reduction to the P.V. reveals the similar lines of attack separated by about half a century in time. The notable difference between the solutions provided is that Dr. Cunningham provides for the azimuth as well as for hour angle and zenith distance. Goodwin, in view of his obvious admiration for Burdwood and his successors, probably thought that Davis' tables were sufficient for the purpose of finding the azimuth.

Goodwin is the author of several works on navigation including *Alpha Beta Gamma Navigation Tables* (1921) and *An Equatorial Azimuth Table* (1921), as well as *Position Line Star Tables*. In addition to these, numerous articles of great interest and value to the student of the history of nautical astronomy appeared under his name during the period *c.* 1895–1930.

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Astrofix and Rectofix Tables

Mr. D. H. Sadler writes:

(1) Through the above contribution by Captain Charles H. Cotter, my attention has been drawn to the fact that the essential principle of the 'Rectofix Tables' is not only quite old but has been incorporated in a set of published tables —the *Position Line Star Tables* (for fixing ship's position by reduction to meridian and prime vertical without logarithmic calculation) by H. B. Goodwin, R.N., J. D. Potter, London, 1906.

https://doi.org/10.1017/S0373463300037553 Published online by Cambridge University Press

Understandably, there are considerable differences in methodology and presentation, but all the essential concepts underlying the method are incorporated in Goodwin's tables; the main improvement introduced by Dr. Cunningham (who was, of course, quite unaware of these tables) is the inclusion of tabulations for the azimuth (*Journal* 17, 17).

Although none of the colleagues to whom I showed my short article called my attention to the existence of Goodwin's tables, I must accept sole responsibility for not having made a more thorough search of the published literature on the subject. This omission does, however, serve to underline the general note in that article on the difficulty of assigning priority for particular methods.

(2) Mr. C. P. Sabelis, Commander of the Nautical College at Den Helder, The Netherlands, has called my attention to an error (due to miscopying) in the equation for the azimuth, which should read

$$\cos A = \tan \phi \sin \Delta H(1 + \tfrac{1}{2} \tan H_0 \sin \Delta H + \dots)$$

The effect is to decrease the stated error in the azimuth.

Manned Spaced Flight Navigation Techniques

from F. D. P. Wicker

I HAVE read with great interest the article entitled 'Manned Space Flight Navigation Techniques' by Major R. C. Henry in the October issue of the *Journal*.

It would appear that much of the imagined difficulty in interplanetary navigation is due to the fact that until now man has really been concerned with fixing his position and controlling his path on a spherical surface, the third-dimensional problem in air navigation has been one of altitude—i.e. definition of the surface concerned. Now, for the first time, we are involved in what at first sight appears to be a truly three-dimensional problem, and its solution appears difficult, partly because we are to be removed from our familiar graticule of earthly meridians and parallels.

If the problem be divided into two parts, an obvious solution presents itself.

At sea, a ship must be on the surface of the water, and is mainly concerned with its position and course on that surface. An aircraft determines its surface of reference by barometric pressure (which by tradition is termed Pressure Altitude and expressed as a linear measure), and again is then concerned with a two-dimensional problem on that surface.

A similar solution presents itself for interplanetary navigation.

The Earth's orbit round the Sun lies in a plane known as the ecliptic, and any space vehicle departing from the Earth must, *ipso facto*, depart from a point on

https://doi.org/10.1017/S0373463300037553 Published online by Cambridge University Press