INTRODUCTION

The present work is intended as a supplement to the well known planetary, lunar and solar tables produced by Bryant Tuckerman (1962, 1964). Since these tables appeared—as volumes 56 and 59 of the Memoirs of the Society—they have continued to prove an invaluable aid to historians of astronomy. An important usage is the dating of ancient and medieval astronomical observations but the tables also have wide application in determining the accuracy of early measurements and calculations.

Our supplementary volume owes its origin to the discovery by the authors—F. Richard Stephenson and Michael A. Houlden (1981)—of significant errors in Tuckerman's tabular positions of Mars. Following a query put to one of us (FRS) by the late Professor A.J. Sachs of Brown University, Providence, R.I. regarding the real accuracy of the tables, we made a systematic comparison between Tuckerman's positions for the Sun and planets and those computed from an integrated ephemeris. Only in the case of the longitude of Mars were errors found to be serious but these could amount to as much as 0.7 deg (considerably more than the Moon's apparent diameter). Before outlining the content of the present work, some remarks are necessary on various aspects of Tuckerman's original memoirs.

EXTENT AND PRECISION OF TUCKERMAN'S TABLES

In two remarkably compact volumes, positions of the five bright planets, together with the Moon and Sun, are tabulated over the entire period between 601 BC (or −600) and AD 1649 at intervals of 5 or 10 days. Co-ordinates are geocentric, relative to the ecliptic—i.e. longitude and latitude. These are more suitable than equatorial co-ordinates (right ascension and declination) for most planetary and lunar calculations and interpolation is much easier. In the case of the Moon and the more rapidly moving planets Mercury and Venus, positions are tabulated every five days, while for the Sun, Mars, Jupiter and Saturn the corresponding interval is 10 days. The hour selected is 16 h UT (4 p.m. Greenwich Civil Time or roughly 7 p.m. at both Babylon and Baghdad).

Tuckerman computed planetary and solar positions to the nearest 0.01 deg, which—provided this accuracy is realised—is more than sufficient for any practical purpose; not until the late seventeenth century was higher precision achieved in measurement. As he stated, it should be possible to interpolate satisfactorily all co-ordinates except the longitude of Mercury when this planet happened to be near inferior conjunction with the Sun. In the case of the Moon, which typically moves through more than 60 degrees every 5 days, there would have been little justification for tabulating positions to the same accuracy since interpolation would not be possible. Instead, Tuckerman rounded both the lunar longitude and latitude to the nearest 0.1 deg. At this level of precision, interpolation again becomes reasonably practicable. However, contrary to Tuckerman's suggestion, the lunar data are not really adequate for analysing such precise observations as eclipses and occultations. In our opinion, the lunar tables are mainly useful as a guide to the approximate location of the Moon; in any case many lunar calculations require a fairly substantial correction for parallax. Only the planetary and solar data are of value for detailed investigations, but here the applications are extensive. A knowledge of the real accuracy of the tabular co-ordinates is thus of prime importance.

In computing the data for the tables, Tuckerman rather surprisingly adopted what was in general outmoded orbital theory. He used the theory of Leverrier (1858–1861) for the Sun and inner planets, that of Gaillot (1904, 1913) for the outer planets and that of Hansen (1857) for the Moon; in each case he adopted modifications to certain of the orbital elements as derived by Schoch (1926). None of the theories cited had formed the basis of the American Ephemeris since well before 1930. However, despite these cautionary remarks, it is not our purpose to criticise Tuckerman's choice of orbital theory. Our main concern is the accuracy of the data in the published tables themselves.

The question of the true precision of the data tabulated by Tuckerman was first considered in detail by the present authors (Stephenson and Houlden, 1981). For this purpose, the then recently developed Long Export Ephemeris (code name DE 102) was used (Newhall et al., 1983). This ephemeris is based on a systematic numerical integration of the equations of motion of the planets.