ducting medium which increases without limit as the rotation of the eddy is increased but which cannot have any effect outside the conductor. In order for there to be an external field, there must be an assymmetrical boundary to the conducting medium surrounding the eddy. In the core, this boundary is provided by the proximity of the poorly conducting mantle. For simplicity the case of a plane boundary at 45° to the axis of rotation has been considered. The external field is proportional to the rotational velocity for small velocities but it is possible that secondary effects will limit the field at very high velocities. The magnetic moment is proportional to a function $f(\alpha)$ where $\alpha = 2\pi\sigma\omega a^2$ is a non-dimensional parameter. σ represents the conductivity, ω the angular velocity and a the radius of the eddy. It has been shown experimentally that $f(\alpha) = \alpha$ for values of α up to 4. For an eddy in the core, α will be of the order of 100 and it is not known whether the proportionality holds as far as this. However, there is no sign of departure from proportionality for values of α up to 4 and *Mr. Lowes* considers that the proportionality does hold approximately up to $\alpha = 100$.

Mr. Lowes concluded that it is possible to account for the magnitude of the non-dipole part of the Earth's magnetic field by eddy currents induced in eddies near the surface of the core. It is not possible at present to account for the secular variation because of the short periods which occur. This variation must originate within 30 Km of the core's surface, because of its rapidity, and its magnitude is too large to be accountable by eddies only 30 Km in diameter, while the decay mechanism of larger eddies has not been studied.

The meeting was adjourned at $12^h\ 40^m$.

ON THE STANDARD OF TIME USED IN THE CALCULATION OF EPHEMERIDES OF THE SUN AND MOON

By J. Jackson

When Brown completed his lunar theory he found that, like Hansen's theory, it left very considerable differences between theory and observation. Following Newcomb's example he introduced an empirical periodic term, but retained the computed secular term. It was soon found that this empirical term did not meet the difficulty and it became more and more clear that the discordances were due to irregular rotation of the Earth. This has been confirmed by the motion of other bodies in the solar system. Everyone will now agree that it is best to remove the empirical term from the lunar tables and adjust the secular terms although the separation of these terms from the remaining fluctuation, B, is largely arbitrary, as has been shown by Brouwer. The additional quadratic term introduced in this way is made up of two parts which we cannot separate by means of observations of the Moon, one part due to a slowing down of the Earth's rate of rotation and the other part due to a change in the period of revolution of the Moon.

Now a comparison of the observations of the Sun with Newcomb's tables made by Spencer Jones for the years 1760—1935 showed that the tables required a correction of

$$+1''\cdot00+2''\cdot97\,T+1''\cdot23\,T^2+0\cdot0748\,B\ldots \qquad (1)$$

where T is measured in centuries from 1900. The coefficient of B is the ratio of the mean motion of the Sun to that of the Moon, so that the terms involving B in the motion of both the Sun and Moon can be explained by the same irregularity in the Earth's rotation. The question arises as to what we should do about the quadratic terms in the solar residuals. If both Newcomb's theory and the observations are free from error these terms like the term in B must be attributed, as far as we know, to irregularities in the Earth's rotation. They differ from the term in B only by the fact that their value can be predicted in the future.

I myself, would prefer to take no action at present with regard to these quadratic terms in the Sun's longitude. The reason for this is that the expression is so poorly determined that it may fail to express the motion of the Sun, at all accurately, during the next 50 years. The numerical values of the expression at intervals of 50 years from 1750 to 2000 are as follows:

1750	$-0''\cdot69$
1800	-0.74
1850	$-0\cdot18$
1900	$+1\cdot00$
1950	$+2\cdot79$
2000	$+5\cdot20$

There are great irregularities in the observations made between 1800 and 1850 so that a considerable range in value of the coefficient of T^2 is allowable. A reduction in the coefficient of T^2 would involve a reduction in that of T and a larger reduction in the value of the quadratic terms for the year 2000.

The only theoretical objection to this course is that an error in the adopted motion of the Sun involves an error in the calculation of the solar perturbations of the Moon's motion. This however is not serious as the principal terms in the perturbations due to an error of $5''\cdot20$ in the relative longitudes of the Sun and Moon are

$$0''\cdot009\cos 2D \text{ and } 0''\cdot017\cos(2D-l)$$

with periods of 15 and 32 days respectively (see Sadler, *M.N.* **111**, 628). As the adopted error of $5''\cdot20$ may be erroneous by a considerable fraction of its amount it does not appear to me to be necessary to introduce these alterations at the present time. The fact that a new theory of the Sun's motion is contemplated is an additional reason for delaying action. Changes in the basis for calculating an ephemeris should not be made more frequently than is really necessary.

If however we decide that the error of Newcomb's tables is large enough for correction two methods of proceeding are possible. The traditional way would be to apply a correction to the Sun's mean longitude of

$$-1''\cdot00-2''\cdot97T-1''\cdot23T^2$$

with the minute corrections to the perturbations of the Moon. If this were done together with the alterations to the lunar ephemeris described in the first paragraph the remaining residuals for both the Sun and Moon would theoretically indicate the same irregularities in the Earth's rotation.

It has, however, been decided to proceed in a different way: to assume that Newcomb's tables of the Sun are correct and that the whole of the expression (1) is to be attributed to an irregularity in U.T. (or G.M.T.)—the time used in comparing the observed with the computed positions. The positions of the Sun will therefore be computed as previously, but the argument will be interpreted not as U.T. but as E.T. (ephemeris time) where

$$\text{E.T.} = \text{U.T.} + \frac{365^{\text{s}}{\cdot}24}{15}(1{\cdot}00 + 2{\cdot}97T + 1{\cdot}23T^2 + 0{\cdot}0748B)$$

$$= \text{U.T.} + 24^{\text{s}}{\cdot}349 + 72^{\text{s}}{\cdot}3165T + 29^{\text{s}}{\cdot}9497T^2 + 1{\cdot}821B.$$

The lunar ephemeris as at present computed must be considered as computed for U.T. + $1{\cdot}821B$ and in order that it may be computed for the same E.T. as for the Sun it will be necessary to apply to the Moon's mean longitude the additional correction of

$$-13{\cdot}37(1''{\cdot}00 + 2''{\cdot}97T + 1''{\cdot}23T^2)$$

$$\text{or } -13''{\cdot}37 - 39''{\cdot}71T - 16''{\cdot}44T^2$$

When this has been done and the observations reduced as usual in terms of U.T. the residuals in seconds of arc for both the Sun and Moon can be converted into E.T.—U.T. by the appropriate factors of

$$\frac{365{\cdot}24}{15} \text{ and } \frac{27{\cdot}32}{15}.$$

All ephemerides, apart from the introduction of empirical terms, are calculated on what is believed to be a rigorous dynamical foundation. No ephemerides calculated in advance can take account of fluctuations in the Earth's rate of rotation. We must be careful to recognize that the introduction of new quadratic terms into the calculation of the ephemeris will, like the old U.T. or G.M.T. only give us something approximating to a dynamical, inertial or Newtonian time after allowance has been made for the residuals shown by the observations. In fact as soon as we recognize that the difference between observed and computed places are to be attributed to irregularities in time and not to errors in theory or observation the time used in the past in the calculations has as good a right as the new time to be called ephemeris time. The justification for the alterations must lie in the hope that the corrections given to U.T. to reduce it to E.T. will be the same for the Sun and Moon.

In our ordinary time determinations, if we find that one star gives a systematically different correction from the others, we alter its adopted right ascension to bring it into line. At some time in the future, let us hope the distant future, it will be found that the reductions from U.T. to E.T. given by the Sun and Moon will differ. We shall be able to make them agree by the alteration of the ephemeris of the one or the other. If our present theories hold it will be possible to do this by the application of quadratic terms to the mean longitude of the Moon (or Sun). The difference between my point of view and that of others is that I do not think it yet necessary to apply a correction of this kind as there is too great an uncertainty in its amount.

1952 October 8.