LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Variation in the Speed of Rotation of the Earth since June 1955

TIME and frequency comparisons have been made since June 1955 between the National Physical Laboratory, Teddington, and the U.S. Naval Observatory, Washington, with the ultimate purpose of establishing the value of the transition frequency of cæsium, (4,0) ⇌ (3,0), in terms of the second of Ephemeris Time based on the orbital motion of the Moon[1,2]. The second of Ephemeris Time is being determined at the Naval Observatory from photographic observations of the Moon, and will be reported on later.

As an intermediate step, the frequency of cæsium is currently being determined with respect to the second of Universal Time, called UT2, which is based on the rotation of the Earth. This frequency is denoted ν_U. The intervals between time signals from *WWV* (Washington, D.C., U.S.A.) and *GBR* (Rugby, U.K.) are measured at the National Physical Laboratory in terms of the cæsium standard, and at the Naval Observatory in terms of UT2. By using signals near the first of each month, the average frequency for the intervening month is intercompared with a probable error of 3 parts in 10^{10}.

If it is assumed that the time occupied by a specified number of vibrations of the National Physical Laboratory standard is constant, we may use it to determine changes in the speed of rotation of the Earth. Such changes would be indicated by changes in ν_U. The precision of the cæsium standard is so high that the accuracy with which the changes in speed of rotation can be determined depends almost entirely on the accuracy with which Universal Time can be determined. The results given here are based on observations made with the photographic zenith tubes at Washington, D.C., and Richmond, Florida, which are known to be instruments of high accuracy.

In order to interpret changes in ν_U, it is necessary to describe the types of variation in speed of rotation and how UT2 is computed.

There are three types of variation in speed: secular, irregular and periodic. The first, due to tidal friction, is too small to be significant here. Irregular variation refers to departures from the average speed of rotation which continue for the order of 5 or 10 years. This effect has been surmised but not previously exhibited. Periodic terms have been found with periods of 1 year, 0·5 year, 27·6 days and 13·6 days[3]. The first two of these terms comprise what is known as the seasonal variation.

By international agreement, an empirical correction for seasonal variation has been applied since January 1, 1956, in obtaining the time called UT2. The formula adopted by the Bureau International de l'Heure is:

$$\Delta SV = 0{\cdot}022^s \sin 2\pi t - 0{\cdot}017^s \cos 2\pi t - 0{\cdot}007^s \sin 4\pi t + 0{\cdot}006^s \cos 4\pi t$$

where t is the fraction of a year.

The terms of period 27·6 days and 13·6 days are eliminated by the smoothing process used in obtaining the adopted UT2 published in the *Time Service Bulletins* of the U.S. Naval Observatory. Hence, UT2 represents, in effect, the speed of rotation of the Earth when freed of periodic terms.

The values of ν_U since June 1955 are shown in Fig. 1. In addition to month-to-month variations which are of an accidental nature, there is seen to be a systematic trend. The length of the day was a minimum about September 1955 (speed of rotation at maximum) and has been increasing at a practically constant rate since then (speed of rotation decreasing).

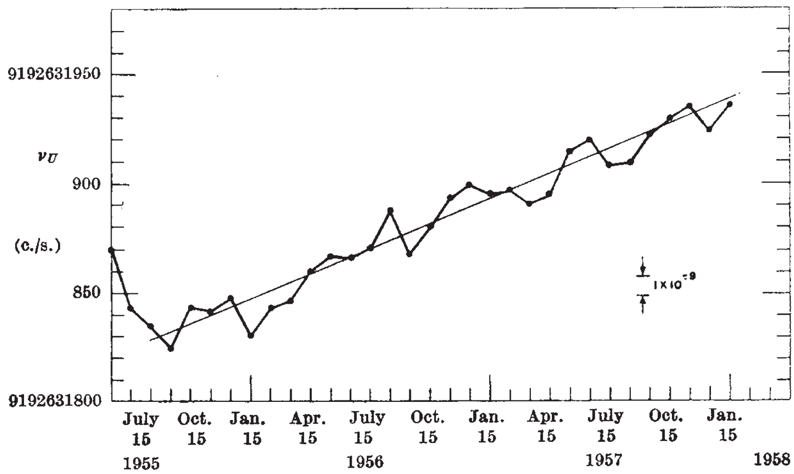

Fig. 1. Frequency of the cæsium resonance in terms of UT2

ν_U can be well represented since September 1955 by a straight line. This means that the seasonal variation for the past two years as determined with the aid of the cæsium standard is practically the same as determined with the aid of quartz-crystal clocks for several years previous to 1955.

Fig. 1 represents the non-periodic portion of the variation in the speed of rotation of the Earth. Since September 1955, this has been a constant deceleration of 5 parts in 10^9 per year, equivalent to an increase in the period of rotation of 0·43 msec. a year. This deceleration is about fifty times as large as that attributed to tidal friction. It is probable that it represents the irregular variation, but further observations are needed to confirm this.

L. ESSEN
J. V. L. PARRY

National Physical Laboratory,
Teddington, Middlesex.

WM. MARKOWITZ
R. G. HALL

U.S. Naval Observatory,
Washington 25, D.C.

March 12.

[1] Essen, L., and Parry, J. V. L., *Phil. Trans. Roy. Soc.*, A, **250**, 45 (1957).
[2] Markowitz, W., and Hall, R. G., *Astrophys. J.*, **62**, 25 (1957).
[3] Markowitz, W., *Astrophys. J.* **60**, 171 (1955).