A NOTE ON SHORTT CLOCK NUMBER 8
AT SYDNEY OBSERVATORY.


(Manuscript received, August 17, 1937. Read, September 1, 1937.)

Since April, 1936, some time has been devoted to Shortt Clock Number 8 at Sydney Observatory. The clock has been in use as the standard sidereal clock since the beginning of May, 1937.

The clock is contained in a small brick room which is situated in the cellar of the building. The internal dimensions of the clock chamber are 4 ft. × 4 ft. × 6½ ft. high. The copper case of the free pendulum is fastened by four ½-inch bolts to the old stone wall of the cellar, about 3 ft. thick.

The losing rate of these clocks decreases with reduction of pressure until a minimum is reached, when further reduction of pressure increases the rate on account of increase of the arc of the pendulum. It is obviously advantageous to run the clock at this minimum value, as small changes in pressure would have less effect on the rate. This effect is well known (1) (2) and the clock has been run at a variety of pressures in order to determine where its minimum rate occurs. The performance is similar to that of other Shortt clocks. No trouble has been experienced in keeping the case air-tight.

A graduated scale attached to the lower end of the pendulum and read by a microscope is provided for reading the arc of the pendulum. Due to deterioration of the scale the arc was read only with difficulty and no great precision in 1936. While the clock has been sealed further deterioration has occurred (perhaps due to attack by mercury vapour from the pressure gauge (3)) and reading is now almost impossible. It seemed, however, desirable to try some quantitative explanation of change of rate with pressure.
Variation of the clock rate depends on change of period of the pendulum due to

(1) change of arc,
(2) change of pressure,
(3) change of temperature.

The arc, of course, depends on the rate of supply of energy to the pendulum and the pressure.

The period of a pendulum is given by

\[ P_\alpha = P_0 \left( 1 + \frac{1}{4} \sin^2 \frac{\alpha}{2} + \frac{9}{64} \sin^4 \frac{\alpha}{2} + \ldots \right) \]

\( \alpha \) being the semi-amplitude of the pendulum. The correction due to arc keeping the square terms is

\[ \frac{\alpha^2}{16} \cdot P_0 \] (\( \alpha \) in radians)

making an increase in daily rate due to arc

\[ \alpha^2 \times 4 \times 569 \times 10^{-4} \text{ secs. per day} \] \hspace{1cm} (A)

\( \alpha \) being the semi-amplitude in minutes of arc.

On energy considerations an approximate representation of the relation between pressure and arc might be given by

\[ c_2 p \alpha^2 + c_1 \alpha - c = 0 \] \hspace{1cm} (B)

where \( c_2, c_1, \) and \( c \) are constants and \( p \) is the pressure. The first term corresponds to the energy loss per second due to a force varying as the pressure and velocity of swing. The second term is the friction-viscosity loss, and the third term the energy supply per second. Using some observed values of arc we obtain

\[ \begin{aligned} c &= 69.4 \ c_1 \\ c_1 &= 585 \times c_2 \\ p &= \frac{40600}{\alpha^2} - \frac{585}{\alpha^2} \end{aligned} \] \hspace{1cm} (D)

Where \( p \) is expressed in centimetres of mercury and \( \alpha \) in minutes of arc. After corrections for arc represented in (A) and (E) are applied, there remain corrections for temperature and pressure.

The daily rate increases \( 0.263 \) second per day for each centimetre of mercury rise in pressure. \hspace{1cm} (F)

The temperature coefficient of the clock is \( +0.0059 \) second per day per degree centigrade. The values found for Shortt 3 and Shortt 11 were \( 0.00508 \) and \( 0.00454 \) respectively. \hspace{1cm} (3)

When the clock was first sealed the weight to be left on the free pendulum was wrongly estimated and the clock had a gaining rate of almost two seconds per day. Fig. 1 shows the variation of rate with pressure according to these
formulæ. The curve has been drawn using the value $-3.995s_+corrections$ found from the relations (A), (E) and (F). The crosses represent observed rates, corrected to $15.3\,^\circ\,C$.

The minimum occurs near $1.5$ centimetres pressure. This is a little lower than the pressure found for Shortt $3^{(1)}$

**FIG. 1.**

at Greenwich. The clock is being used with the pressure in the case $1.64$ centimetres of mercury.

The weight on the free pendulum has been altered and the following are some errors of the clock from transit observations since May 28.

There is a secular increase of rate of $0.020$ second per day per hundred days, so that the daily rate is given by

$$-0.0538 + 0.020t + 0.0059 (T^{-11.9}),$$

where $t$ is measured in units of one hundred days and $T$ in degrees centigrade. This is similar to the rates of the Shortt clocks Number 3 and Number $11^{(4)}$ at Greenwich.
A recent paper by Openshaw and Eobinson (J.C.S., 1937, 941) describes certain preliminary experiments on the synthesis of substances allied to strychnine. About twelve years ago Professor Eobinson suggested to the author that he should carry out some experiments having a bearing on the question of the constitution of strychnine, and a number of preliminary experiments were made at the time. These were later elaborated and a few of the results recorded by Openshaw and Eobinson had already been obtained by the author some years before. Changes in the conception of the constitution of the strychnine molecule removed the need for a completion of the earlier projected experiments and the results remained fragmentary. However, they are now collected and placed on record.

Strychnine and brucine have long been known to contain an acid amide grouping, and it is now fairly definitely established that the nitrogen atom of this grouping is part of a dihydroindole nucleus (cf. e.g. Eobinson, Bakerian Lecture, Proc. Roy. Soc. London, 1931, 130a, 431). For a long time this nitrogen was held to be present in a reduced quinoline nucleus. Koenigs (Berichte, 1900, 33, 218) had shown that tetrahydroquinolyl-2-p-propionic acid lactam (I), closely resembles strychnine in many of its reactions, particularly in the ease with which the lactam ring can be opened by the action of sodium ethoxide and closed again with acid, just as strychnine can be converted to strychnic acid and this again cyclised to strychnine. Clemo, Perkin and Eobinson (J.C.S., 1924, 1763), also, in a long synthetical investigation of substances having formulae closely related to that put forward by Perkin and Eobinson in 1910 (J.C.S., 97, 305) for strychnine, showed that anhydrohexahydroacrmdoline acetic acid (II) reacted readily with methyl alcoholic potassium hydroxide to give

Using the relations (D) and taking the pressure as 1.64 cms. of mercury, equation (B) becomes

\[ 4 \cdot 04 \times 10^{-5}c^2 + 1.44 \times 10^{-2}c = (c + d), \]

where the rate of energy supply is now regarded as variable by a quantity d. \( \alpha \) is the semi-amplitude in minutes of arc. According to this relation a variation of one-third per cent. in the energy supply would change the semi-arc by about 10'. This corresponds to a change in daily rate of almost a hundredth of a second. The rate of supply of energy to the clock is 0.083 centimetre gramme per half minute, about a fortieth of which is lost in friction on the impulse wheel and pivots.\(^5\) A change of about a seventh of the value of the frictional losses would thus cause a change in arc and rate, which is quite large for these clocks. It seems that some of the irregularities which have been observed in this and other clocks\(^6\) must be due to this cause.

References.


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