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GRAVITY IN SOUTH AFRICA.

BY R. A. LEHFELDT, D.Sc., F.R.S.S.Af.

(Read March 16, 1910.)

Shortly after arriving in Johannesburg, the author made a rough determination of " g ," as that quantity was at the time unknown. The result, 9.786 metres/sec.², was published in the *Philosophical Magazine*, Nov., 1906. As the South African tableland is one of the only two really large tablelands in the world—the other being Tibet—a certain geophysical interest attaches to gravity measurements there, and it was hoped that they might be continued with proper apparatus. The author applied to the hydrographical department of the Austro-Hungarian Government, which has long shown itself interested in the matter, and the Director very courteously and promptly lent the author three pendulums of the well-known Sterneck pattern, such as had been used for gravity measurements at coast stations by officers of the Austrian navy, together with subsidiary apparatus. The author desires to convey his thanks to the Austro-Hungarian Government for this loan, and to others for incidental assistance rendered during the observations—the South African railways for transport facilities, the Post Office for the use of telephone lines, and especially to Mr. R. T. A. Innes, Director of the Transvaal Observatory; Mr. Hough, of the Royal Observatory, Cape of Good Hope; and Capt. Lacerda, of the Observatory, Lourenço Marques.

Although the method of measurement is well known, it has not always been easy to find satisfactory conditions for observation in a new country. This, coupled with the limitations of time at the disposal of the author—vacations only being available—has resulted in but a small number of measurements being carried out. These, however, throw some light on the problem of the tableland, and it is therefore thought worth while to publish them without waiting for more.

STATIONS.

Johannesburg, South African School of Mines and Technology
(formerly Transvaal Technical Institute).

Latitude $26^{\circ} 11' 47''$ S.
Longitude $28^{\circ} 2' 32''$ E.
Altitude 1,749 metres.

The measurements were carried out in the basement of the old Telephone Tower, the pendulum (on the "pfeiler-stativ") resting on a massive concrete block: temperature was satisfactorily steady. The times were observed sometimes by means of signals transmitted from the sidereal clock of the Observatory over the telephone lines to a relay and thence by a separate battery to the coincidence apparatus, and sometimes by the Carroll chronometer.* Although in the centre of the town, the building was free from shaking. The land slopes very slightly upwards to the north, near the building, but it may be taken as practically flat for half a kilometre in every direction. Further away the land slopes downward both northwards and southwards, Johannesburg being placed on the ridge of the Witwatersrand hills. The underlying strata are shales and quartzites, to a depth of at least 1,500 metres below the surface: density probably about 2.7.

Johannesburg Observatory.

Latitude $26^{\circ} 10' 55''$ S.
Longitude $28^{\circ} 4' 30''$ E.
Altitude 1,805 metres.

The pendulum was placed on the ledge of the east window of the basement, being screened from the sun by a wooden shutter, the "pfeiler-stativ" used, with the usual glass cover. The times were observed by signals from the mean-time (Riefler) clock of the Observatory; this was compared chronographically with the sidereal. Temperature steady, and support solid. The Observatory is situated at the highest point of the town, on a ridge of quartzite, the land falling away sharply both to north and south.

Vereeniging (Post Office).

Latitude $26^{\circ} 40\frac{1}{2}'$ S.
Longitude $27^{\circ} 55\frac{1}{2}'$ E.
Altitude 1,436 metres.

The pendulum was placed on the "pfeiler-stativ" on the ledge of a window, which was too narrow to allow the usual cover to be used: it

* The best set out of several is alone quoted below. More weight is to be given to the measurements at Johannesburg Observatory.

was screened from draughts by paper. The temperature was moderately constant. The coincidence apparatus was worked by the Carroll chronometer (with electric contacts), and the latter was checked by means of telephonic signals from the Johannesburg Observatory. There was, however, some difficulty in getting these signals, which had to traverse about 50 miles, owing to imperfections in the line. Only pendulum 62 was used.

The surface and the underlying strata are *very* flat; surface rocks, clay and shales.

Cape of Good Hope (Royal Observatory).

Latitude	33° 56' 3" S.
Longitude	16° 8' 26" E.
Altitude	16 metres.

The measurements were made in the space under the floor of the Maclean telescope, the pendulum resting (on the "pfeiler-stativ") on a massive buttress of the wall. Stability and temperature conditions very good. The coincidence apparatus could not be worked by the clock (a Riefler) direct, so the Carroll chronometer was used, and compared by ear with a sounder worked by the Riefler. The single coincidences could not be obtained in this way nearer than $\frac{1}{10}$ second. The rate of the chronometer varied a good deal during the day of observation, and an attempt was made to draw a curve of the variation and correct the observed periods by that (Fig. p. 125); but the results were uncertain.

The Observatory is situated on a slight eminence in an otherwise flat, sandy country. The mass of Table Mountain (about 1,000 metres high) lies from 1 to 2 kilometres away to the SW., and stretches to a considerable distance, embracing about a quarter of the horizon.

Lourenço Marques Observatory.

Latitude	26° 2' 31" S.
Longitude	32° 19' 48" E.
Altitude	55 metres.

A large brick pillar was built in the basement of the clock-house, and the pendulum erected on it, and provided with the usual glass cover. The oscillations were in the EW. direction, the telescope being to the south. The temperature was very constant; the pillar was tested for stability and appeared quite satisfactory. The coincidence apparatus was worked direct by the sidereal clock (Strasser and Rohde).

The Observatory is placed on a small, sandy plateau, extending for 300 or 400 metres to the east (towards the sea), and more than a kilometre in all other directions. A map of the coast was examined

with a view to estimating the correction for variations of altitude of land and depth of sea; it was concluded that the attraction could safely be taken as that of an indefinite plateau of height 55 m. and density about 2.

CRITICISM OF METHOD.

It is unnecessary to describe the method of using the Sterneck apparatus, which has already been described more than once; but some remarks on it have occurred to the writer during the course of the work.

Three pendulums—numbered 23, 44, and 62—were provided, and two stands, one for use on a pillar, the other against a wall; of the two stands the former has been used, for the most part. The corrections to be applied are for—

- (a) Rate of clock.
- (b) Amplitude.
- (c) Temperature.
- (d) Density of air.
- (e) Oscillation of support.

(a) In order to render this as certain as possible, it is desirable to extend the observations as nearly as possible over twenty-four hours, so as to make use of the average rate of the clock determined by observations of the stars. In the case of a good observatory clock it is probable that no sensible diurnal variation of the rate occurs; though this is a point not quite satisfactorily settled; whilst the variation in rate of a good clock from one day to another is hardly sufficient to affect the value of “*g*” by more than one in a million. Chronometers, however, usually show a diurnal variation—an effect that has been but little studied; and when moved about from place to place undoubtedly suffer irregular changes of rate; hence it is all the more important in this case to distribute the observations evenly between the star-transits.

(b) Presents no difficulty.

(c) The pendulums are old ones, made of brass. An error of $\frac{1}{20}$ degree corresponds to one-millionth in the value of “*g*.” The correction, as given in the tables, appears very large, sometimes exceeding 1,000 units,* but this is because the reduction is made to 0° C. The limits of temperature in the South African observations are about 12° to 24°, and it would be preferable to make the reduction to a standard temperature such as 20°, when its true value would be apparent. When working in a cellar there is no difficulty in finding the temperature correctly to $\frac{1}{20}$ degree or less. At the same time it would be much better to use pendulums of invar.

* The unit is the seventh decimal of the (single) period in seconds. It is about 1/5,080,000 part in the period or 1/2,540,000 in “*g*.”

Two thermometers were provided, of which one (No. 53) was used throughout. It had been standardised in 1894 and again in 1895. It was expected that no further change could occur after the first few years, and unfortunately the author neglected to standardise it again till August, 1910, when it was found to have changed very much (see table, p. 90). It was tested by a thermometer (P.T.R. 28,629) possessing the 0° and 100° points, and these were found correct. The results given below are according to the 1910 standardisation.

(d) There is no difficulty in finding the density of the air with sufficient accuracy. This correction depends, therefore, only on the accuracy of the formula given by Sterneek, according to which the period varies by an amount proportional to the change of density. For corrections *c* and *d* the values obtained in Austria* have been used, viz.:—

49·26 units (sidereal time) per 1° C.

542·0 „ „ „ „ for a change of density equal to the density of air at normal temperature and pressure. The pressure correction might be eliminated by swinging the pendulum *in vacuo*, did the apparatus permit.

(e) This correction is by far the most difficult. It consists of two parts—the oscillation of the pendulum support, and that of the pillar or wall on which the support is placed. With regard to the former, it is assumed that the correction is always the same, and therefore disappears in comparative measurements. The stability of the pillar or wall is tested by giving it ten properly timed blows with a wooden rod which has been pressed against a spring with a force of 5 kilogs. If the succession of blows does not induce a measureable amplitude of swing in the pendulum it is assumed that the effect of vibration of the pillar is negligible. More satisfactory methods have been worked out of late, but they involve the use of different patterns of apparatus (stands carrying more than one pendulum at a time), and so could not be used.

From this review of the corrections it might be supposed that when working under favourable conditions the results should agree to within 5 units. Experience shows that this is not the case. Even at a well-equipped observatory, such as that of Pola, differences of 20 units are often noticed, and on repeating the observations after an interval, much more. The same is true of the South African measurements—a fact which long puzzled and disconcerted the present writer. The larger differences may be due to secular changes of length in the pendulums, but this would not account for the irregular variations from day to day. Eventually a cause for this was found in variations in

* Veröff. Hydrog. Amts. der K. K. Kriegsmarine, No. 7, p. 1. Pola, 1898.

strength of the current used to work the electromagnet of the coincidence apparatus.

In the Sterneek apparatus a flash is produced each time the current is made or broken by the clock: there are thus two independent series of flashes, either of which may be used to determine the coincidence period. Unfortunately, before the influence of current variation was thought of, no record was kept as to whether the make or break was used. The influence of current variation is much greater on make than on break, but is still perceptible on the latter, as certain special observations showed. A set of 10 coincidences was observed with the aid of current from two accumulators, which remained practically steady at $9\frac{1}{2}$ (arbitrary units); the battery was then exchanged for three leclanches, which gave a current of $7\frac{1}{2}$ at first, falling to 6; with this another set was observed 25 coincidences later than the first. The accumulators were then restored and a third set taken, 50 coincidences later than the first. When observations were made by attraction of electromagnet ("make") the results were:—

Mean interval for 50 coincidences = 1549·31s. whence $c = 30\cdot9862$
 „ „ first 25 „ = 776·22 „ $c = 31\cdot0488$

The first value of c is the true one, the second is lengthened because the current was weakened and the electromagnet pulled over more slowly in the second half of the observations than in the first. The real delay in the action of the magnet is given by $776\cdot22 - \frac{1549\cdot31}{2} = 1\cdot67$; this is about $\frac{1}{20}$ coincidence, and indicates a delay of $\frac{1}{20}$ period of pendulum, or $\frac{1}{40}$ sec.

When the recovery of the spring ("break") was used, the result is much less inaccurate, although when the current is weak the spring recovers a little quicker. Similar observations gave—

Mean interval for 50 coincidences = 1549·47s. whence $c = 30\cdot9894$
 „ „ first 25 „ = 774·57 „ $c = 30\cdot9828$

i.e., the recovery of the magnet is accelerated by—

$$\frac{1549\cdot47}{2} - 774\cdot57 = \cdot16 \text{ or } \frac{1}{200} \text{ coincidence, or by } \frac{1}{400} \text{ sec.}$$

The effect of these errors would be to make the calculated period of the pendulum too short by 70 units and too long by 7 units respectively.

It seems probable that there may be some change in length of the pendulums also. No. 23 gives results that are notably more irregular than the other two, though no defect in it could be discovered.

To summarise, we may say that the chief sources of error in the experiment, and kinds of error they give rise to, are:—

Irregularity in rate of clock	Diurnal.
Variation of temperature	Diurnal.
Unsteadiness of support	Local.
Change in Length	Secular.
Change in strength of current	Irregular.

RESULTS.

	Johannesburg.		Vereeniging.	Cape of Good Hope Observatory.	Lourenço Marques.	Pola.
	School of Mines.	Observatory.				
	0.50					
Period of 23	—	85315	—	82409	83977	7997
„ 44	—	88974	—	86109	87627	8369
„ 62	81833	81870	81522	79038	80536	7664
Diff. 44—23	—	3659	—	3700	3650	372
„ 44—62	—	7104	—	7071	7091	705
Diff. from Pola 23	—	5345	—	2449	4007	—
„ „ 44	—	5280	—	2306	3933	—
„ „ 62	5191	5228	4880	2385	3894	—
Mean	—	5284	—	2413	3945	—
Corresponding difference in “ <i>g</i> ”	2004	2040	1884	931	1523	—
“ <i>g</i> ” observed	9.78638	9.78602	9.78758	9.79711	9.79119	9.80642
“ <i>g</i> ” calc. at sea-level	9.79011	9.79011	9.79046	9.79618	9.79001	9.80584
Correction for altitude	— 538	— 556	— 442	— 5	— 17	— 9
„ „ strata	+ 193	+ 195	+ 160	— 2	+ 4	+ 3
“ <i>g</i> ” calc.	9.78666	9.78650	9.78764	9.79611	9.78988	9.80578
Anomaly	— 28	— 48	— 6	+ 100	+ 131	+ 64

The above table gives a summary of the observations taken at the stations described. The concordance of the measurements is not as good as might be wished, and it seems probable that some secular change in the pendulums is the cause of this. Accordingly the old observations at Pola may not be properly comparable with those in South Africa, and it would be well to swing the pendulums again at Pola. The absolute values of the anomaly may therefore be wrong; at the same time the general character of it is unmistakable, and there seems no reason to doubt the values found for the difference between sea-level and the plateau. Probably the most trustworthy of all the observations are those at Lourenço Marques and Johannesburg Observatories. These were both done under favourable conditions, and within a month of one another; and as the difference in latitude is trifling, the effect of level stands out with special clearness. The difference in anomaly is between + 131 and — 36 or 177 units, pointing, as far as one can see, to a greater density of rock in the lower strata near sea-level than on the plateau.

The result may be put in this form :—

$$\begin{aligned} \text{"} g \text{" Lourenço Marques} - \text{"} g \text{" Johannesburg} &= + 517 \\ \text{Difference due to latitude} &= - 10 \\ \therefore \text{Difference due to altitude (1805 m.)} &= + 527 \end{aligned}$$

or 3·4 metres per unit (10^{-5} m./sec.²). The comparison between Lourenço Marques and Vereeniging gives practically the same. This quantity has usually been stated as 5 metres.

An explanation of this, suggested to the writer by Prof. Schwarz, is that the South African plateau is a sort of floating island of lighter rock, the roots of which go down to a depth at which the rock in most regions is denser (of basic material)—something like an ice-floe on water. The suggestion is quite a possible one physically, and it is easy to adjust the arithmetic to it. Thus, supposing the defect in density for a depth of 10 kilometres below sea-level were about 0·5, or if the deficiency were less, but extended to a greater depth, the anomaly in "*g*" would be accounted for.

CALIBRATION OF THERMOMETER 53.

Reading in cm.	Temperature Centigrade.		
	1894.	1895.	1910.
8	8·85	8·60	8·61
9	10·49	10·25	10·18
10	12·10	11·92	11·75
11	13·73	13·55	13·32
12	15·31	15·20	14·89
13	16·94	16·82	16·46
14	18·51	18·40	18·03
15	20·10	20·00	19·60
16	21·71	21·62	21·17
17	23·27	23·20	22·74
18	24·84	24·80	24·31

The last column is equivalent to the equation—

$$t = - 3\cdot95 + 1\cdot57 x.$$

The observations in the tables were reduced by the 1895 calibration. The final results (p. 89) are then corrected to 1910 values.

REMARKS TO TABLES.

The intervals given are for 100 coincidences in the observations at Johannesburg (Telephone Tower), 50 in the other cases.

The amplitude of swing is expressed in scale divisions, each division being approximately 3 mm. The distance from scale to mirror and back to telescope (doubled distance) is measured, and allows of reducing the scale divisions to minutes of arc.

When a mean-time clock or chronometer was used, its rate was expressed by stating the ratio of the length of its second to that of the sidereal clock with which it was compared.

c = period of coincidence.

$s = \frac{c}{2c - 1}$ = period of pendulum.

When a mean-time clock or chronometer was used, the value of s found by it is converted to the value in terms of the sidereal clock before recording in the tables.

u = correction for rate of sidereal clock.

a = amplitude.

t = temperature.

d = density of air.

S = corrected period of pendulum.

S is subsequently corrected for the new calibration of thermometer **53** by the following amounts :—

At Johannesburg (Telephone Tower)	+ 5 units
Vereeniging	+ 17 „
Cape of Good Hope	+ 20 „
Lourenço Marques	+ 17 „
Johannesburg Observatory	+ 14 „

Sidereal clock rates :—

Johannesburg (Telephone Tower) ...	0·25s./day gaining
Vereeniging	0·06s./day losing
Cape of Good Hope	0·15s./day losing

Johannesburg Observatory. Sidereal clock gaining 2·32s./day. Riefler (mean) losing 2·32s./day, *cf.* to sidereal. Hence Riefler rate was correct.

TABLES.

Date, 20.7.08.

Place: Basement of Telephone Tower, Johannesburg.

Pendulum No. **62**.Thermometer No. **53**, 9.03 to 9.10 = 10.36° Cent.

Barometer, 629.2.

Amplitude, 10.0 to 7.1 = 23.2'.

Doubled Distance, 3.8.

Rate of Clock (Carroll), 1.0027463.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
9	22	29.8	10	23	52.2	3682.4
	23	7.1		24	30.2	3.1
	23	43.3		25	5.8	2.5
	24	20.4		25	44.0	3.6
	24	56.9		26	19.2	2.3
	25	34.2		26	57.5	3.3
	26	10.6		27	33.2	2.6
	26	48.1		28	11.0	2.9
	27	24.3		28	47.0	2.7
	28	1.9		29	24.6	2.7

Mean 3682.81

$$\begin{array}{l} c = 36.8281 \\ 2c-1 = 72.6562 \end{array} \left. \vphantom{\begin{array}{l} c = 36.8281 \\ 2c-1 = 72.6562 \end{array}} \right\} \text{mean time}$$

$$s = 0.5082736 \text{ sidereal}$$

$$u = -14$$

$$a = -14$$

$$t = -510$$

$$d = -432$$

$$S = 0.5081766$$

Date, 20.7.08.

Place: Basement of Telephone Tower, Johannesburg.

Pendulum No. **62**.

Thermometer No. **53**, 9·10 to 9·10 = 10·42° Cent.

Barometer, 629·2.

Amplitude, 7·1 to 5·2 = 16·7'.

Doubled Distance, 3·8.

Rate of Clock (Carroll), 1·0027463.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
10	23	52·2	11	25	11·9	3679·7
	24	30·2		25	50·0	9·8
	25	5·8		26	25·5	9·7
	25	44·0		27	3·6	9·6
	26	19·2		27	38·9	9·7
	26	57·5		28	17·5	80·0
	27	33·2		28	52·3	79·1
	28	11·0		29	30·8	9·8
	28	47·0		30	6·1	9·1
	29	24·6		30	44·6	80·0

Mean 3679·65

$$\left. \begin{array}{l} c = 36·7965 \\ 2c-1 = 72·5930 \end{array} \right\} \text{mean time}$$

$$s = 0·5082798 \text{ sidereal}$$

$$u = - 14$$

$$a = - 7$$

$$t = - 513$$

$$d = - 432$$

$$S = 0·5081832$$

Date, 20.7.08.

Place : Basement of Telephone Tower, Johannesburg..

Pendulum No. **62**.

Thermometer No. **53**, 9.19 to 9.21 = 10.60° Cent.

Barometer, 628.6.

Amplitude, 10.5 to 7.2 = 23.0'.

Doubled Distance, 3.8.

Rate of Clock (Carroll), 1.0027463.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
2	21	33.8	3	22	53.0	3679.2
	22	10.2		23	29.7	9.5
	22	47.5		24	6.4	8.9
	23	24.0		24	42.8	8.8
	24	0.9		25	20.1	9.2
	24	37.6		25	56.5	8.9
	25	14.4		26	33.6	9.2
	25	51.0		27	10.3	9.3
	26	28.0		27	47.5	9.5
	27	4.8		28	24.0	9.2

Mean 3679.17

$$\begin{array}{l} c = 36.7917 \\ 2c-1 = 72.5834 \end{array} \left. \vphantom{\begin{array}{l} c = 36.7917 \\ 2c-1 = 72.5834 \end{array}} \right\} \text{mean time}$$

$$s = 0.5082807 \text{ sidereal}$$

$$u = -14$$

$$a = -14$$

$$t = -522$$

$$d = -431$$

$$S = 0.5081826$$

Date, 20.7.08.

Place : Basement of Telephone Tower, Johannesburg.

Pendulum No. **62**.

Thermometer No. **53**, 9.20 to 9.22 = 10.62° Cent.

Barometer, 628.6.

Amplitude, 7.4 to 5.0 = 16.8'.

Doubled Distance, 3.8.

Rate of Clock (Carroll), 1.0027463.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
3	22	53.0	4	24	10.9	3677.9
	23	29.7		24	47.5	7.8
	24	6.4		25	24.8	8.4
	24	42.8		26	0.8	8.0
	25	20.1		26	38.2	8.1
	25	56.5		26	14.7	8.2
	26	33.6		27	51.9	8.3
	27	10.3		28	28.3	8.0
	27	47.5		29	5.6	8.1
	28	24.0		29	42.0	8.0

Mean 3678.08

$$\left. \begin{array}{l} c = 36.7808 \\ 2c-1 = 72.5616 \end{array} \right\} \text{mean time}$$

$$s = 0.5082837 \text{ sidereal}$$

$$u = - 14$$

$$a = - 7$$

$$t = - 523$$

$$d = - 431$$

$$S = 0.5081862$$

Date, 20.7.08.

Plate : Basement of Telephone Tower, Johannesburg.

Pendulum No. **62**.

Thermometer No. **53**, 9.16 to 9.21 = 10.58° Cent.

Barometer, 629.2.

Amplitude, 10.4 to 7.2 = 22.9'

Doubled Distance, 3.8.

Rate of Clock (Carroll), 1.0027463.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
8	22	47.0	9	24	4.9	3677.9
	23	23.6		24	41.9	8.3
	24	0.6		25	18.8	8.2
	24	37.1		27	55.3	8.2
	25	14.1		26	32.2	8.1
	25	50.7		27	8.9	8.2
	26	27.4		27	46.1	8.7
	27	4.3		28	22.5	8.2
	27	41.1		28	59.6	8.5
	28	17.9		29	36.1	8.2

Mean 3678.25

$$\begin{array}{l} c = 36.7825 \\ 2c-1 = 72.5650 \end{array} \left. \begin{array}{l} \\ \end{array} \right\} \text{mean time}$$

$$s = 0.5082823 \text{ sidereal}$$

$$u = -14$$

$$a = -14$$

$$t = -521$$

$$d = -432$$

$$S = 0.5081842$$

Date, 20.7.08.

Place : Basement of Telephone Tower, Johannesburg.

Pendulum No. **62**.

Thermometer No. **53**, 9.21 to 9.27 = 10.66° Cent.

Barometer, 629.2.

Amplitude, 7.4 to 5.0 = 16.8'.

Doubled Distance, 3.8.

Rate of Clock (Carroll), 1.0027463.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
9	24	4.9	10	25	22.8	3677.9
	24	41.9		16	1.1	9.2
	25	18.8		26	37.0	8.2
	25	55.3		27	13.9	8.6
	26	32.2		27	50.6	8.4
	27	8.9		28	27.0	8.1
	27	46.1		29	4.0	7.9
	28	22.5		29	40.7	8.2
	28	59.6		30	17.8	8.2
	29	36.1		30	54.5	8.4

Mean 3678.31

$$\begin{array}{l} c = 36.7831 \\ 2c-1 = 72.5662 \end{array} \left. \begin{array}{l} \\ \end{array} \right\} \text{mean time}$$

$$s = 0.5082822 \text{ sidereal}$$

$$u = - 14$$

$$a = - 7$$

$$t = - 527$$

$$d = - 432$$

$$S = 0.5081842$$

Date, 4.10.08.

Place : Vereeniging Post Office.

Pendulum No. **62**. No cover.

Thermometer No. **53**, 13·41 to 13·51 = 14·46 = 17·55° Cent.

Barometer, 645·4.

Double Distance, 3·4 m.

Rate of Clock (Carroll), 1·0027324.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
11	1	22·1	11	31	59·5	1837·4
	1	59·3		32	37·1	7·8
	2	35·8		33	12·8	7·0
	3	13·0		33	50·7	7·7
	3	49·1		34	26·4	7·3
	4	27·0		35	4·1	7·1
	5	2·6		35	39·7	7·1
	5	40·4		36	18·0	7·6
	6	16·1		36	53·0	6·9
	6	54·0		37	31·3	7·3

Mean 1837·32

$$\begin{array}{l} c = 36·7464 \\ 2c-1 = 72·4928 \end{array} \left. \vphantom{\begin{array}{l} c \\ 2c-1 \end{array}} \right\} \text{mean time}$$

$$s = 0·5082822 \text{ sidereal}$$

$$u = + 4$$

$$a = - 18$$

$$t = - 864$$

$$d = - 429$$

$$S = 0·5081515$$

Date, 4.10.08.

Place : Vereeniging Post Office.

Pendulum No. **62**. No cover.

Thermometer No. **53**, 13·41 to 13·71 = 13·56 = 17·70° Cent.

Barometer, 640·4.

Amplitude, 7·8 to 6·5 = 7·15 = 21·8'.

Doubled Distance, 3·4 m.

Rate of Clock (Carroll), 1·0027324.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
11	31	59·5	12	2	36·8	1837·3
	32	37·1		3	15·3	8·2
	33	12·8		3	50·2	7·4
	33	50·7		4	29·0	8·3
	34	26·4		5	4·0	7·6
	35	4·1		5	42·4	8·3
	35	39·7		6	17·6	7·9
	36	18·0		6	56·0	8·0
	36	53·0		7	31·2	8·2
	37	31·3		8	9·9	8·6

Mean 1837·98

$$\begin{array}{l} c = 36·7596 \\ 2c-1 = 72·5192 \end{array} \left. \vphantom{\begin{array}{l} c = 36·7596 \\ 2c-1 = 72·5192 \end{array}} \right\} \text{mean time}$$

$$s = 0·5082798 \text{ sidereal}$$

$$u = + 4$$

$$a = - 13$$

$$t = - 872$$

$$d = - 429$$

$$S = 0·5081488$$

Date, 4.10.08.

Place: Vereeniging Post Office.

Pendulum No. **62**.

Thermometer No. **53**, 13·92 to 14·22 = 14·07 – 18·51° Cent.

Barometer, 638·6.

Amplitude, 10·0 to 8·0 = 9·0 = 27·2'.

Doubled Distance, 3·4 m.

Rate of Clock (Carroll), 1·0027324.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
12	53	37·8	13	24	14·1	1836·3
		14·0			50·6	·6
		51·1			27·9	·8
		27·9			04·0	·1
		04·7			40·9	·2
		41·0			17·9	·9
		18·1			54·3	·2
		54·5			31·1	·6
		31·6			07·8	·2
		08·0			44·6	·6

Mean 1836·45

$$\left. \begin{array}{l} c = 36·7290 \\ 2c-1 = 72·4580 \end{array} \right\} \text{mean time}$$

$$s = 0·5082856 \text{ sidereal}$$

$$u = + 4$$

$$a = - 19$$

$$t = - 912$$

$$d = - 426$$

$$S = 0·5081503$$

Date, 4.10.08.

Place: Vereeniging.

Pendulum No. **62**.

Thermometer No. **53**, 14.11 to $14.33 = 14.22 = 18.75^\circ$ Cent.

Barometer, 638.6.

Amplitude, 8.3 to $6.8 = 7.55 = 23.0'$.

Doubled Distance, 3.4.

Rate of Clock (Carroll), 1.0027324.

Coincidences —

h.	m.	s.	h.	m.	s.	Diff.
13	24	14.1	13	54	50.5	1836.4
		50.6			27.6	7.0
		27.9			04.0	6.1
		04.0			40.7	6.7
		40.9			17.4	6.5
		17.9			54.2	6.3
		54.3			30.9	6.6
		31.1			07.9	6.8
		07.8			44.6	6.8
		44.6			21.5	6.9

Mean 1836.61

$$\begin{array}{l} c = 36.7322 \\ 2c-1 = 72.4644 \end{array} \left. \vphantom{\begin{array}{l} c = 36.7322 \\ 2c-1 = 72.4644 \end{array}} \right\} \text{mean time}$$

$$s = 0.5082850 \text{ sidereal}$$

$$u = + 4$$

$$a = - 14$$

$$t = - 924$$

$$d = - 426$$

$$S = 0.5081490$$

Date, 4.10.08.

Place : Vereeniging Post Office.

Pendulum No. **62**.

Thermometer No. **53**, 14.45 to 15.08 = 14.76 = 19.69° Cent.

Barometer, 638.3.

Amplitude, 10.0 to 7.9 = 8.95 = 27.1'.

Doubled Distance, 3.4 m.

Rate of Clock (Carroll), 1.0027324.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
14	55	26.2	15	26	00.6	1834.4
		03.1			37.3	4.2
		39.5			13.7	4.2
		16.4			50.7	4.3
		52.7			26.8	4.1
		30.0			04.4	4.4
		06.1			40.0	3.9
		43.5			18.0	4.5
		19.6			52.9	3.3
		57.0			31.3	4.3

Mean 1834.16

$$\begin{array}{l} c = 36.6832 \\ 2-c1 = 72.3664 \end{array} \left. \vphantom{\begin{array}{l} c = 36.6832 \\ 2-c1 = 72.3664 \end{array}} \right\} \text{mean time}$$

$$s = 0.5082942 \text{ sidereal}$$

$$u = + 4$$

$$a = - 19$$

$$t = - 970$$

$$d = - 425$$

$$S = 0.5081532$$

Date, 4.10.08.

Place : Vereeniging Post Office.

Pendulum No. 62.

Thermometer No. 53, 15.00 to 15.14 = 15.07 = 20.11° Cent.

Barometer, 638.3.

Amplitude, 8.4 to 6.6 = 7.5 = 22.8'.

Doubled Distance, 3.4 m.

Rate of Clock (Carroll), 1.0027324.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
15	26	00.6	15	56	34.9	1834.3
		37.3			11.9	4.6
		13.7			48.0	4.3
		50.7			25.1	4.4
		26.8			01.7	4.9
		04.4			38.3	3.9
		40.0			15.0	5.0
		18.0			51.9	3.9
		52.9			28.5	5.6
		31.3			05.3	4.0

Mean 1834.49

$$\left. \begin{array}{l} c = 36.6898 \\ 2c-1 = 72.3796 \end{array} \right\} \text{mean time}$$

$$s = 0.5082929 \text{ sidereal}$$

$$u = + 4$$

$$a = - 14$$

$$t = - 991$$

$$d = - 424$$

$$S = 0.5081504$$

Date, 17.1.10.

Place : Royal Observatory, Cape of Good Hope.

Pendulum No. **23**. No cover.

Thermometer No. **53**, 16·38 to 16·36 = 22·21° Cent.

Barometer (Aneroid), 755·2.

Amplitude, $\left\{ \begin{array}{l} 10\cdot0 \\ 8\cdot8 \end{array} \right\}$ to $\left\{ \begin{array}{l} 9\cdot0 \\ 7\cdot8 \end{array} \right\} = 8\cdot9 = 30\cdot3'$.

Doubled Distance, 3·0 m.

Rate of Clock (Carroll), 1·0028600.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
12	17	20·0	12	47	43·4	1823·4
		56·9			22·0	4·9
		32·8			56·3	3·5
		10·0			35·0	5·0
		45·6			09·2	3·6
		23·0			48·0	5·0
		58·5			22·0	3·5
		36·0			01·3	5·3
		11·4			34·8	3·4
		49·1			14·5	5·4

Mean 1824·30

$$\left. \begin{array}{l} c = 36\cdot4860 \\ 2c-1 = 71\cdot9720 \end{array} \right\} \text{mean time}$$

$$s = 0\cdot5083971 \text{ sidereal}$$

$$u = + 17$$

$$a = - 25$$

$$t = - 1094$$

$$d = - 498$$

$$S = 0\cdot5082371$$

Date, 17.1.10.

Place : Roy. Obs. C. G. H.

Pendulum No. 44.

Thermometer No. 53, 16.50 to 16.44 = 22.36° Cent.

Barometer, 755.0.

Amplitude, $\left\{ \begin{smallmatrix} 8.8 \\ 8.8 \end{smallmatrix} \right\}$ to $\left\{ \begin{smallmatrix} 8.1 \\ 8.1 \end{smallmatrix} \right\} = 8.45 = 28.7'$.

Doubled Distance, 3.0

Rate of Clock (Carroll), 1.0028755.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
14	17	30.0	14	46	24.9	1734.9
		05.2			00.3	5.1
		39.4			34.4	5.0
		14.6			09.7	5.1
		48.8			43.8	5.0
		23.9			19.1	5.2
		58.2			53.2	5.0
		33.3			28.7	5.4
		08.4			02.6	4.2
		42.6			38.0	5.4

Mean 1735.03

$$\left. \begin{array}{l} c = 34.7006 \\ 2c-1 = 68.4012 \end{array} \right\} \text{mean time}$$

$$\begin{array}{rcl} s = & 0.5087685 & \text{sidereal} \\ u = & + & 17 \\ a = & - & 23 \\ t = & - & 1102 \\ d = & - & 497 \end{array}$$

$$S = 0.5086080$$

Date, 17.1.10.

Place : Roy. Obs. C. G. H.

Pendulum No. **62**.

Thermometer No. **53**, 16.46 to 16.42 = 22.32° Cent.

Barometer, 754.7.

Amplitude, 8.6 to 8.0 = 8.3 = 28.3'.

Doubled Distance, 3.0.

Rate of Clock (Carroll), 1.0028790.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
16	8	43.9	16	40	41.3	1917.4
		22.4			20.0	.6
		00.6			58.0	.4
		39.0			36.8	.8
		17.2			14.8	.6
55.7			53.6			.9
34.0			31.2			.2
12.4			09.4			.0
50.6			48.0			.4
29.2			27.0			.8

Mean 1917.51

$$\left. \begin{array}{l} c = 38.3502 \\ 2c-1 = 75.7004 \end{array} \right\} \text{mean time}$$

$$s = 0.5080635 \text{ sidereal}$$

$$u = + 17$$

$$a = - 22$$

$$t = - 1100$$

$$d = - 497$$

$$S = 0.5089033$$

Date, 17.1.10.
 Place : Roy. Obs. C. G. H.
 Pendulum No. **62**.
 Thermometer No. **53**.
 Barometer, 754.9.
 Amplitude, 8.9 to 8.1 = 8.5 = 28.9'.
 Doubled Distance, 3.0.
 Rate of Clock (Carroll), 1.0028740.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
18	2	17.4	58	34	15.0	1917.6
		56.1			54.8	8.7
		34.1			31.9	7.8
		13.0			11.0	8.0
		50.9			48.5	7.6
		29.9			27.8	7.9
		07.4			05.4	8.0
		46.5			44.5	8.0
		24.3			22.0	7.7
		03.5			01.3	7.8

Mean 1917.91

$$\left. \begin{array}{l} c = 38.3582 \\ 2c-1 = 75.7164 \end{array} \right\} \text{mean time}$$

$s =$	0.5080595	sidereal
$u =$	+	17
$a =$	-	23
$t =$	-	1088
$d =$	-	497

$$S = 0.5089004$$

Date, 17.1.10.

Place : Roy. Obs. C. G. H.

Pendulum No. **44**.

Thermometer No. **53**, 16.30 to 16.24 = 22.05° Cent.

Barometer, 755.3.

Amplitude, 9.2 to 8.6 = 8.9 = 30.0'.

Doubled Distance, 3.0.

Rate of Clock (Carroll), 1.0028700.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
20	7	29.4	20	36	23.6	1734.2
		04.2			58.4	.2
		38.7			33.1	.4
		13.5			07.7	.2
		48.2			42.5	.3
		22.7			17.0	.3
		57.5			52.0	.5
		32.3			26.3	.0
		07.0			01.4	.4
		41.5			35.7	.2

Mean 1734.27

$$\begin{array}{l} c = 34.6854 \\ 2c-1 = 68.3708 \end{array} \left. \vphantom{\begin{array}{l} c = 34.6854 \\ 2c-1 = 68.3708 \end{array}} \right\} \text{mean time}$$

$$s = 0.5087690 \text{ sidereal}$$

$$u = + 17$$

$$a = - 25$$

$$t = - 1086$$

$$d = - 498$$

$$S = 0.5086098$$

Date, 17.1.10.

Place: Roy. Obs. C. G. H.

Pendulum No. **23**.

Thermometer No. **53**, 16·07 to 16·02 = 21·70° Cent.

Barometer, 756·5.

Amplitude, 8·2 to 7·2 = 7·7 = 26·2'.

Doubled Distance, 3·0.

Rate of Clock (Carroll), 1·0028685.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
21	54	05·7	22	24	31·1	1825·4
		42·2			07·3	·1
		18·6			44·0	·4
		55·1			20·2	·1
		31·6			57·1	·5
		08·0			33·1	·1
		44·7			10·3	·6
		21·0			46·0	·0
		58·0			23·5	·5
		34·0			59·0	·0

Mean 1825·27

$$\left. \begin{array}{l} c = 36·5054 \\ 2c-1 = 72·0108 \end{array} \right\} \text{mean time}$$

$$s = 0·5083976 \text{ sidereal}$$

$$u = + 17$$

$$a = - 19$$

$$t = - 1069$$

$$d = - 499$$

$$S = 0·5082406$$

Date, 18.1.10.
 Place: Roy. Obs. C. G. H.
 Pendulum No. **23**.
 Thermometer No. **53**, 15·90 to 15·90 = 21·46° Cent.
 Barometer, 756·8.
 Amplitude, 8·1 to 7·1 = 7·6 = 25·9'.
 Doubled Distance, 3·0.
 Rate of Clock (Carroll), 1·0028660.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
7	9	11·1	7	39	38·0	1826·9
		47·3			13·1	5·8
		24·2			51·2	7·0
		00·3			26·0	5·7
		37·4			04·4	7·0
		13·3			39 0	5·7
		50·4			17·6	7·2
		26·4			52·0	5·6
		03·6			30·8	7·2
		39·4			05·0	5·6

Mean 1826·37

$$\begin{array}{l} c = 36\cdot5274 \\ 2c-1 = 72\cdot0548 \end{array} \left. \vphantom{\begin{array}{l} c = 36\cdot5274 \\ 2c-1 = 72\cdot0548 \end{array}} \right\} \text{mean time}$$

$$\begin{array}{l} s = 0\cdot5083920 \text{ sidereal} \\ u = + 17 \\ a = - 18 \\ t = - 1057 \\ d = - 500 \end{array}$$

$$S = 0\cdot5082372$$

Date, 18.1.10.

Place : Roy. Obs. C. G. H.

Pendulum No. 23.

Thermometer No. 53, 16.00 to 16.00 = 21.62° Cent.

Barometer, 757.1.

Amplitude, 8.1 to 7.1 = 7.6 = 25.9'.

Doubled Distance, 3.0.

Rate of Clock (Carroll), 1.0028650.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
9	3	26.2	9	33	51.2	1825.0
		02.2			26.3	4.1
		39.3			04.2	4.9
		15.0			39.3	4.3
		52.3			17.1	4.8
		28.0			52.3	4.3
		05.4			30.2	4.8
		41.0			05.4	4.4
		18.4			43.4	5.0
		54.0			18.2	4.2

Mean 1824.58

$$\left. \begin{array}{l} c = 36.4916 \\ 2c-1 = 71.9832 \end{array} \right\} \text{mean time}$$

$$s = 0.5083985 \text{ sidereal}$$

$$u = + 17$$

$$a = = 18$$

$$t = = 1065$$

$$d = - 500$$

$$S = 0.5082419$$

Date, 18.1.10.

Place : Roy. Obs. C. G. H.

Pendulum No. **23**.

Thermometer No. **53**, 16.15 to 16.13 = 21.84° Cent.

Barometer, 756.6.

Amplitude, 8.1 to 7.3 = 7.7 = 26.2'.

Doubled Distance, 3.0.

Rate of Clock (Carroll), 1.0028640.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
11	1	12.6	11	31	38.0	1825.4
		49.0			14.2	.2
		25.6			51.0	.4
		02.1			27.2	.1
		38.7			04.0	.3
		15.0			40.2	.2
		51.8			17.0	.2
		28.0			53.2	.2
		04.9			29.9	.0
		41.0			06.3	.3

Mean 1825.23

$$\begin{aligned} c &= 36.5046 \\ 2c-1 &= 72.0092 \end{aligned} \left\{ \begin{array}{l} \text{mean time} \end{array} \right.$$

$$s = 0.5083954 \text{ sidereal}$$

$$u = + 17$$

$$a = - 19$$

$$t = - 1076$$

$$d = - 499$$

$$S = 0.5082377$$

Date, 11.7.10.

Place: Observatory, Lourenço Marques.

Pendulum No. 62.

Thermometer No. 53, 14.76 to 14.74 = 19.60° Cent.

Barometer, 762.0.

Amplitude, 9.2 to 8.4 = 8.8 = 28.3'.

Doubled Distance, 3.20 m.

Rate of Clock, 0.145 s./day losing.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
6	3	33.7	6	29	23.2	1549.5
		04.9			54.5	.6
		35.8			25.2	.4
		07.0			56.5	.6
		37.8			27.3	.5
		09.0			58.6	.6
		39.8			29.1	.3
		11.0			Minute signal of	clock interfered
		41.7			31.2	.5
		12.9			02.5	.6

Mean 1549.51

$$\begin{array}{l} c = 30.9902 \\ 2c-1 = 60.9804 \end{array} \left. \begin{array}{l} \\ \end{array} \right\} \text{mean time}$$

$$s = 0.5081994 \text{ sidereal}$$

$$u = + 9$$

$$a = - 21$$

$$t = - 966$$

$$d = - 507$$

$$S = 0.5080509$$

Date, 11.7.10.

Place : Observatory, Lourenço Marques.

Pendulum No. **44**.

Thermometer No. **53**, 14.73 to 14.72 = 19.56° Cent.

Barometer, 760.6.

Amplitude, 8.6 to 8.0 = 8.3 = 26.7'.

Doubled Distance, 3.20 m.

Rate of Clock, 0.145s./day losing.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
8	7	39.2	8	31	27.2	1428.0
		08.1			56.3	8.2
		36.4			24.4	8.0
		05.3			53.4	8.1
		33.3			21.6	8.3
		02.2			50.6	8.4
		30.6			18.7	8.1
		59.2			47.8	8.6
		27.6			15.8	8.2
		56.7			44.7	8.0

Mean 1428.15

$$\left. \begin{array}{l} c = 28.5630 \\ 2c-1 = 56.1260 \end{array} \right\} \text{mean time.}$$

$$s = 0.5089083 \text{ sidereal}$$

$$u = + 9$$

$$a = - 19$$

$$t = - 964$$

$$d = - 506$$

$$S = 0.5087603$$

Date, 11.7.10.

Place : Observatory, Lourenço Marques.

Pendulum No. 23.

Thermometer No. 53, 14.78 to 14.80 = 19.67° Cent.

Barometer, 760.5.

Amplitude, 8.9 to 8.1 = 8.5 = 27.4'.

Doubled Distance, 3.20 m.

Rate of Clock, 0.145s./day losing.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
10	9	16.8	10	34	04.8	1488.0
		46.8			34.8	8.0
		16.4			04.2	7.8
		46.4			34.3	7.9
		15.9			03.7	7.8
		46.0			33.9	7.9
		15.4			03.1	7.7
		45.4			33.4	8.0
		14.9			02.8	7.9
		45.0			32.9	7.9

Mean 1487.89

$$\begin{array}{l} c = 29.7578 \\ 2c-1 = 58.5156 \end{array} \left. \vphantom{\begin{array}{l} c = 29.7578 \\ 2c-1 = 58.5156 \end{array}} \right\} \text{mean time}$$

$$s = 0.5085448 \text{ sidereal}$$

$$u = + 9$$

$$a = - 20$$

$$t = - 968$$

$$d = - 505$$

$$S = 0.5083964$$

Date, 11.7.10.

Place: Observatory, Lourenço Marques.

Pendulum No. **23**.

Thermometer No. **53**, 14.80 to 14.80 = 19.68° Cent.

Barometer, 760.5.

Amplitude, 8.9 to 8.0 = 8.45 = 27.2'.

Doubled Distance, 3.20 m.

Rate of Clock, 0.145s./day losing.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
12	9	19.3	12	34	07.3	1488.0
		49.1			37.2	8.1
		18.8			06.8	8.0
		48.7			36.9	8.2
		18.3			06.3	8.0
		48.2			36.4	8.2
		17.9			05.8	7.9
		47.9			36.0	8.1
		17.5			05.4	7.9
		47.4			35.5	8.1

Mean 1488.05

$$\begin{array}{l} c = 29.7610 \\ 2c-1 = 58.5220 \end{array} \left. \begin{array}{l} \\ \\ \end{array} \right\} \text{mean time}$$

$$s = 0.5085437 \text{ sidereal}$$

$$u = + 9$$

$$a = - 20$$

$$t = - 969$$

$$d = - 505$$

$$S = 0.5083952$$

Date, 11.7.10.

Place: Observatory, Lourenço Marques.

Pendulum No. 44.

Thermometer No. 53, 14.83 to 14.82 = 19.72° Cent.

Barometer, 760.7.

Amplitude, 9.2 to 8.2 = 8.7 = 28.0'.

Doubled Distance, 3.20 m.

Rate of Clock, 0.145 s./day losing.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
14	3	54.9	14	27	42.5	1427.6
		24.0			11.8	7.8
		52.0			39.6	7.6
		21.0			08.9	7.9
		48.9			36.8	7.9
		18.1			06.0	7.9
		46.2			33.8	7.6
		15.4			03.2	7.8
		43.3			30.9	7.6
		12.5			00.0 (?)	7.5

Mean 1427.74

$$\begin{array}{l} c = 28.5548 \\ 2c-1 = 56.1096 \end{array} \left. \vphantom{\begin{array}{l} c = 28.5548 \\ 2c-1 = 56.1096 \end{array}} \right\} \text{mean time}$$

$$s = 0.5089112 \text{ sidereal}$$

$$u = + 9$$

$$a = - 21$$

$$t = - 971$$

$$d = - 506$$

$$S = 0.5087623$$

Date, 11.7.10.

Place : Observatory, Lourenço Marques.

Pendulum No. **62**.

Thermometer No. **53**, 14·85 to 14·87 = 19·78° Cent.

Barometer, 761·4.

Amplitude, 8·8 to 7·8 = 8·3 = 26·7'.

Doubled Distance, 3·20 m.

Rate of Clock, 0·145s./day losing.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
16	14	04·2	16	39	53·4	1549·2
		35·6			24·5	8·9
		06·3			55·4	9·1
		37·5			26·5	9·0
		08·2			57·3	9·1
		39·5			28·4	8·9
		10·1			59·6 (?)	9·5
		41·5			30·4	8·9
		12·1			01·0 (?)	8·9
		43·4			32·3	8·9

Mean 1549·00

$$\begin{array}{l} c = 30·9800 \\ 2c-1 = 60·9600 \end{array} \left. \begin{array}{l} \\ \end{array} \right\} \text{mean time}$$

$$s = 0·5082020 \text{ sidereal}$$

$$u = + 9$$

$$a = - 19$$

$$t = - 974$$

$$d = - 506$$

$$S = 0·5080530$$

Date, 11.7.10.

Place: Observatory, Lourenço Marques.

Pendulum No. 62.

Thermometer No. 53, 14.82 to 14.82 = 19.71° Cent.

Barometer, 762.0.

Amplitude, 7.5 to 6.9 = 7.2 = 23.2'.

Doubled Distance, 3.20 m.

Rate of Clock, 0.145s./day losing.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
18	14	33.6	18	40	22.9	1549.3
		04.8			54.0	9.2
		35.6			24.9	9.3
		06.7			56.0	9.3
		37.4			26.9	9.5
		08.7			58.0	9.3
		39.4			28.9	9.5
		10.7			—	—
		41.4			30.8	9.4
		12.7			02.0	9.3

Mean 1549.34

$$\left. \begin{array}{l} c = 30.9868 \\ 2c1 = 60.9736 \end{array} \right\} \text{mean time.}$$

$$s = 0.5082001 \text{ sidereal}$$

$$u = + 9$$

$$a = - 14$$

$$t = - 971$$

$$d = - 507$$

$$S = 0.5080518$$

Date, 12.7.10.

Place : Observatory, Lourenço Marques.

Pendulum No. **44**.

Thermometer No. **53**, 14.55 to 14.53 = 19.26° Cent.

Barometer, 762.4.

Amplitude, 9.2 to 8.3 = 8.75 = 28.2'.

Doubled Distance, 3.20.

Rate of Clock, 0.145s./day losing.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
1	58	09.3	2	21	57.9	1428.6
		38.0			26.3	.3
		06.6			54.8	.2
		35.3			23.6	.3
		03.9			52.1	.2
		32.1			20.6	.5
		01.0			49.2	.2
		29.5			17.8	.3
		58.0			46.3	.3
		26.6			14.9	.3

Mean 1428.32

$$\begin{aligned} c &= 28.5664 \text{ } \frac{1}{2} \text{ mean time.} \\ 2c-1 &= 56.1328 \text{ } \frac{1}{2} \end{aligned}$$

$$s = 0.5089072 \text{ sidereal}$$

$$u = + 9$$

$$a = - 21$$

$$t = - 949$$

$$d = - 508$$

$$S = 0.5087603$$

Date, 12.7.10.

Place: Observatory, Lourenço Marques.

Pendulum No. **23**.

Thermometer No. **53**, 14.56 to 14.58 = 19.31° Cent.

Barometer, 763.1.

Amplitude, 8.4 to 7.8 = 8.1 = 26.0'.

Doubled Distance, 3.20.

Rate of Clock, 0.145s./day losing.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
1	5	05.9	4	29	54.0	1488.1
		35.9			23.9	.0
		05.3			53.5	.2
		35.4			23.6	.2
		04.8			53.0	.2
		34.9			23.0	.1
		04.5			52.7	.2
		34.5			22.6	.1
		03.9			52.2	.3
		34.0			22.1	.1

Mean 1488.15

$$\left. \begin{array}{l} c = 29.7630 \\ 2c-1 = 58.5260 \end{array} \right\} \text{mean time.}$$

$$s = 0.5085432 \text{ sidereal}$$

$$u = + 9$$

$$a = - 18$$

$$t = - 951$$

$$d = - 508$$

$$S = 0.5083964$$

Date, 21.7.10.

Place : Observatory, Johannesburg.

Pendulum No. **62.**

Thermometer No. **53**, 11·52 to 11·57 = 14·44° Cent.

Barometer, 620·45.

Amplitude, 10·2 to 9·2 = 97 = 19·2'.

Doubled Distance, 5·2.

Rate of Clock (Riefler mean time), correct = 1·0027379.

Coincidences—

h. m. s.	h. m. s.	Diff.
11 9 19·7	11 39 53·1	1833·4
56·0	29·2	3·2
33·0	06·6	3·6
09·2	42·5	3·3
46·1	20·1	4·0
22·5	55·8	3·3
59·5	33·7	4·2
35·8	09·2	3·4
12·9	46·4	3·5
49·4	22·6	3·2

Mean 1833·51

$$\begin{array}{l} c = 36·6702 \\ 2c-1 = 72·3404 \end{array} \left\{ \begin{array}{l} \text{mean time} \end{array} \right.$$

$$s = 0·5082997 \text{ sidereal}$$

$$u = 0$$

$$a = - 10$$

$$t = - 711$$

$$d = - 420$$

$$S = 0·5081856$$

Date, 18.7.10.

Place: Observatory, Johannesburg.

Pendulum No. **44**.

Thermometer No. **53**, 11.48 to 11.40 = 14.28° Cent.

Barometer, 619.7.

Amplitude, 10.3 to 9.5 = 9.9 = 19.6'.

Doubled Distance, 5.2.

Rate of Clock (Riefler mean time), correct = 1.0027379.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
12	15	37.8	12	43	23.7	1665.9
		10.0	—	—	—	—
		44.8	—	—	—	—
		16.8	45	02.0		5.2
		51.0		37.0		6.0
		23.6		08.6		5.0
		58.0		43.7		5.7
		30.1		15.3		5.2
		04.5		50.2		5.7
		36.7		21.9		5.2

Mean 1665.49

$$\begin{array}{l} c = 33.3098 \\ 2c-1 = 65.6196 \end{array} \left. \vphantom{\begin{array}{l} c \\ 2c-1 \end{array}} \right\} \text{mean time}$$

$$s = 0.5090094 \text{ sidereal}$$

$$u = 0$$

$$a = -10$$

$$t = -704$$

$$d = -420$$

$$S = 0.5088960$$

Date, 2.17.10.

Place : Observatory, Johannesburg.

Pendulum No. **23**.

Thermometer No. **53**, 11.62 to 11.67 = 14.62° Cent.

Barometer, 619.2.

Amplitude, 11.4 to 10.0 = 10.7 = 21.2'.

Doubled Distance, 5.2.

Rate of Clock (Riefler mean time), correct = 1.0027379.

Coincidences—

h.	m.	s.	h.	m.	s.	Diff.
13	46	18.0	14	15	25.7	1747.7
		52.2			59.8	.6
		27.8			35.5	.7
		02.4			09.7	.3
		37.8			45.7	.9
		12.2			20.0	.8
		47.8			55.4	.6
		22.2			29.8	.6
		57.8			05.2	.4
		32.2			39.7	.5

Mean 1747.61.

$$\begin{array}{l} c = 34.9522 \\ 2c-1 = 68.9044 \end{array} \left. \begin{array}{l} \\ \end{array} \right\} \text{mean time}$$

$$s = 0.5086452 \text{ sidereal}$$

$$u = 0$$

$$a = -12$$

$$t = -720$$

$$d = -419$$

$$S = 0.5085301$$