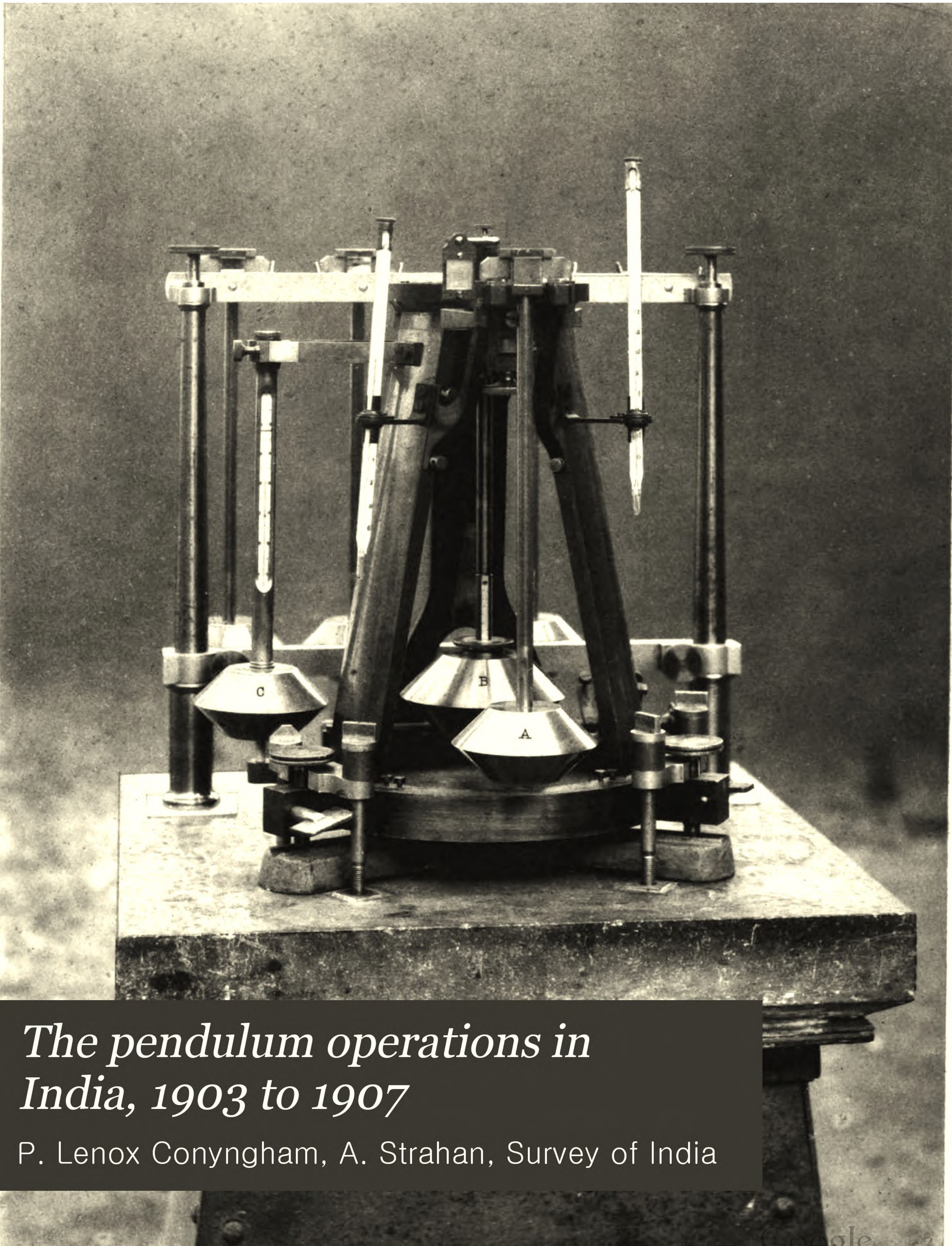
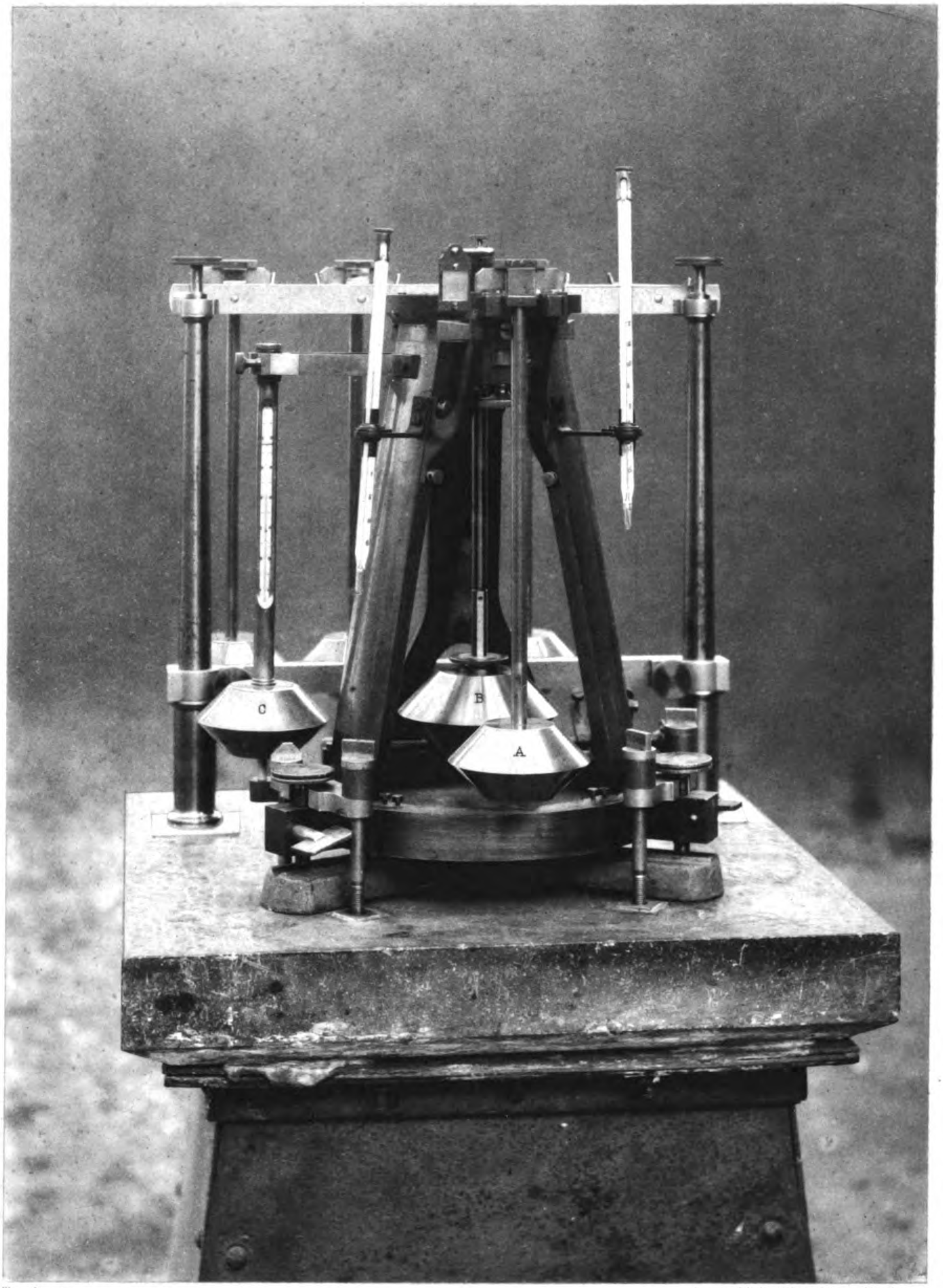


The pendulum operations in India, 1903 to 1907

P. Lenox Conyngham, A. Strahan, Survey of India

THE PENDULUM APPARATUS.



Photogravure.

Survey of India Offices, Calcutta, March 1908.

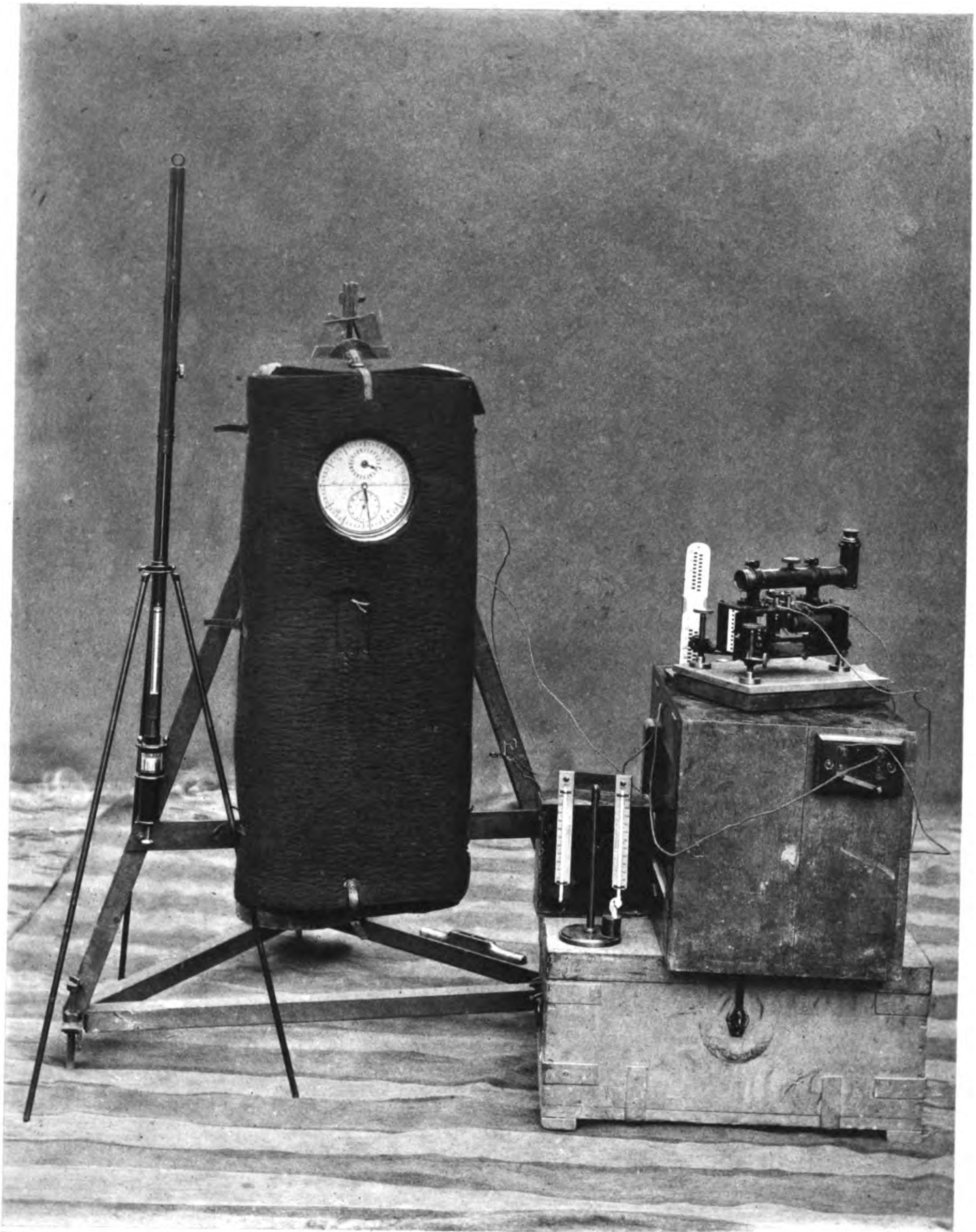
STAND WITH PENDULUMS IN POSITION FOR THE FLEXURE OBSERVATION.

A Invariable Pendulum.

B. Auxiliary Pendulum.

C. Dummy Pendulum containing Thermometer.

THE PENDULUM APPARATUS.



Photogravure

Survey of India Offices, Calcutta, March, 1908

CLOCK, FLASH BOX AND ACCESSORIES.

Survey of India.

PROFESSIONAL PAPER—No. 10.

THE

PENDULUM OPERATIONS IN INDIA

1903 to 1907

BY

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PREFACE.

This paper contains a detailed account of all the observations made with the Indian half-seconds pendulum apparatus from the date of its purchase in 1903 to the end of the season 1906-07.

A gravimetric survey of the whole country is the ultimate object of the operations, of which the first few are here described, and nothing less will serve to elucidate all the problems that it is sought to solve; but this is a far off ideal and as it is well to have some more immediate goal in view, to fix ideas and to give definiteness to the programme of work of each year, two primary problems were attacked in the first instance.

These were, to ascertain the extent to which visible excesses of mass, such as mountains, are compensated by deficient density; and to test with the pendulums the truth of the inferences drawn by Colonel Burrard from the Astronomical Latitudes and Longitudes, that is to say, to find out whether there exists a chain of excessive density running more or less parallel to the Himalayas, distant some 150 miles from them and extending from the Bay of Bengal to the Punjab.

Captain Basevi's celebrated observation in 1871, with the Royal Society's Pendulums, at Moré at an elevation of 15400 feet above the sea, gave a result which seemed to show that the mountain mass was entirely compensated by deficient density: that is to say, his value of gravity was the same as would have been expected if the observation had been made in a balloon floating at a height of 15400 feet above a plain at sea level. There are reasons however for doubting whether this observation was trustworthy. It was made under circumstances of great difficulty and Captain Basevi was in very bad health.

The story of how this indomitable observer lost his life while pushing on from Moré to a still higher altitude need not be retold here, but it is proper to remark that, though every care was taken by his successors in reducing the Moré observations, it is possible that had he lived he might have had suggestions to make which would have altered the value deduced from his work.

Colonel Burrard has shewn, in Professional Paper No. 5, that total compensation is incompatible with the deflections of the plumb-line revealed by the latitude observations at and near the foot of the hills. Archdeacon Pratt's theory of mountain compensation was in a large measure based on the smallness of the deflections observed at Kaliána, but Colonel Burrard has shewn that this is explained by the presence of a line of excessive density, in the position mentioned above, and that many other apparent anomalies, which were unknown to the archdeacon, may also be accounted for in the same way.

No station of altitude equal to that of Moré has been visited with the new apparatus, but five stations in the Himalayas and two in the Baluchistan hills are included in the present series, the highest being Sandakphu, 11766 feet.

At all these points a deficiency of density is revealed, but in no case does it amount to total compensation and at Sandakphu it is equivalent to not much more than one-third of the apparent mass. Under all the submontane and mountain stations there appears to be a deficiency which is nearly constant in amount and is not proportional to the height of the station; this applies not only to the Himalayan stations but to those on and at the foot of the Baluchistan ranges also.

Colonel Burrard's hidden chain has been crossed in two places and in each it has made its presence unmistakeably felt.

In the plains of Bengal its crest lies near the station of Kisnapur, (latitude 25° 2′, longitude 88° 28′) and in the Punjab somewhere between Ferozepore and Montgomery (about latitude 30° 50′, longitude 74° 30′).

Noteworthy features are the trough of great deficiency which lies at the foot of the mountains of Northern India, and the way in which this deficiency gradually diminishes and finally gives place to an excess of density at a distance of 100 to 150 miles from them. This is seen on five different lines, namely:—

(i.) On the line extending southwards from Rájpur to Gesupur:

(ii.) On the line from Siliguri to Kisnapur and Chatra:

(iii.) On the line from Patháнkot to Ferozepore.

These three lines start from the base of the Himalayas.

(iv.) On the line from Dera Gházi Khan near the base of the Suleman Mountains through Multán to Montgomery, and lastly (v.) there is the station of Sibi at the foot of the Baluchistan hills with Jacobabad 120 miles further from them.

These several ranges of hills are all of similar structure. It will be of great interest to ascertain whether the same features present themselves in the case of the mountains of Southern and Central India which are of a different character. Observations which will throw light on this are in progress.

As far as the work has now advanced it will be seen that the theory of total compensation of mountain masses is not supported and that the truth of Colonel Burrard's deductions from the observed deflections of the plumb-line is confirmed.

But observations at stations further in among the hills are required before we can make any general statement as to the amount of compensation that affects the Himalayan masses as a whole, and numerous stations along and on both sides of the hidden chain must be visited to enable us to form a correct idea of its position and shape. With regard to the Himalayas I do not think that stations at great altitudes will be the best; the difficulties of carrying out observations of adequate accuracy in very exposed positions are enormous, and the important point is, in my opinion, to get away from the fringe of the hills rather than to get up as high as possible.

In carrying out these observations and in preparing this account of them I have received help from many quarters and I take this opportunity of tendering my most grateful acknowledgments.

First and foremost I have to thank Colonel Burrard, to whom the inception of the undertaking is wholly due, for constant encouragement, advice and support which have smoothed many difficulties from my path.

Mr. Eccles has helped me much in preparing the account for the press and has given me the benefit of his knowledge in many ways. Captain H. M. Cowie has frequently assisted me in the observatory and has read many of the proofs.

My Assistant Babu Hanuman Prasad, who has been with me throughout the work in India, has done his share both of the observations and of the computations to my entire satisfaction; the late Babu Shiv Nath Saha, Head Computer of the Trigonometrical Survey Office, on whom I have placed great reliance for many years, checked my figures; his successor Babu Ishan Chandra Dev, B.A., has made a great number of valuable suggestions and assisted by Babu Mukundananda Acharya has corrected all proofs.

In various parts of India I have been indebted to Officers of the Civil Service, of the Public Works Department, and of the Military Works Service and to others for the loan of rooms in which to erect the apparatus, and I have received much personal hospitality at their hands.

The list of those to whom my thanks are due would be a long one and I must confine myself to a general expression of gratitude for their many kindnesses.

December, 1908. G. P. LENOX CONYNGHAM.

CHAPTER I.

The Pendulum Observations made at Kew and Greenwich Observatories in 1903.*

The pendulum observations of which an account is given in this Chapter had their origin in the decision of the Government of India to extend, with the aid of a new portable apparatus, the operations which were brought to a close in 1870.

Professor F. R. Helmert, Director of the Central Bureau of the International Geodetic Association, was asked for advice as to the form of apparatus to be acquired and he recommended the use of a half-seconds pendulum equipment as designed by Colonel von Sterneck. He further offered to obtain the instruments from Vienna, to have them fitted with the additions necessary for the determination of the flexure correction, to test the whole apparatus and to make determinations of the constants of the temperature and density corrections.

The India Office adopted Professor Helmert's suggestions and gratefully accepted the offer of his valuable assistance. The equipment was therefore ordered through the Geodetic Institute in Potsdam, where the observations for determining the instrumental constants were made by Professor L. Haasemann under Professor Helmert's direction.

In October 1902 Major Burrard and I happened to be on leave in England, and went to Potsdam in order to study the method of observing. We were most cordially received, and Professor Haasemann, who had had much experience in pendulum work, gave up the whole of his time to our instruction.

The apparatus was not quite complete at this time nor had the determinations of the constants been made, so at our departure we did not take the equipment with us, but left it to be sent over to England later on.

Base station.

As the apparatus does not give the absolute value of the force of gravity, but only the difference from that at a Base station, the next step was to choose a Base and there swing the pendulums.

Kew Observatory was selected because it had been the Base Station of the earlier Indian series, and Dr. R. T. Glazebrook, F.R.S., Director of the National Physical Laboratory, most kindly gave his permission and promised all necessary assistance. Professor Helmert had asked that a fresh determination of the constants might be made at Kew as a check on the values obtained at Potsdam, and this also Dr. Glazebrook kindly undertook. In the meantime however the suggestion had been made by Mr. W. H. M. Christie, C.B., F.R.S., Astronomer Royal,

* An abridged account of these observations appeared in the *Proceedings of the Royal Society* —*A. Vol. 78.*

that the opportunity should be taken of making swings at Greenwich as well as at Kew so as to obtain a value of the difference in g at these observatories.

The Secretary of State for India sanctioned the addition of this work to the originally proposed standardisation and deputed Major Burrard and me to undertake it with the assistance of the Kew Staff.

The apparatus.

The apparatus was made by E. Schneider of Vienna after Colonel von Sterneck's design. The pendulums are four in number, all of precisely similar appearance and with very nearly equal times of vibration. Their numbers are 137, 138, 139 and 140. They are made of brass heavily gilded, and have agate edges on which to vibrate; each has a small vertical mirror securely fastened to its head just above the line of these edges.

The stand on which the pendulums hang during the observation is solidly made of brass in the form of a truncated cone with three large apertures in the conical surface. It rests on three foot-screws which are capable of being firmly clamped. The stand carries a highly polished agate plane for the reception of the agate edges.

This plane is pierced by an oblong hole through which the head of the pendulum which is to be suspended is passed from underneath; after passage the pendulum is turned through a right angle so that the knife-edge bridging the hole, rests on the agate surface. In order to avoid accidental injury to the agates, such as might happen if the edges had to be placed on the plane by hand, the edges are divided into two portions, inner and outer, and stirrups are provided on which the operator places the latter in the first instance; then by the action of a slow-motion screw the stirrups are gently lowered from under the edges until the inner or true portions rest on the plane, the outer being entirely free.

In the base of the stand a lever is provided for starting the oscillation of the pendulum, it has an adjusting screw so that an oscillation of any desired amplitude can be imparted.

The pendulums swing in air at the natural pressure, but are protected by a cover from draughts.

The flash-box constitutes the other essential part of the equipment. It contains a contrivance whereby a shutter, moving up and down under the control of a break-circuit clock, allows a flash of light to pass through a slit at every beat or every alternate beat. This flash of light is reflected by the mirror on the vibrating pendulum into a small telescope fixed on the top of the flash-box; the times at which the flash passes the horizontal wire in the field of the telescope correspond to the coincidences of the free pendulum with the clock pendulum; the intervals between such passages are therefore the coincidence intervals of the pendulums.

The coincidence interval of each of the pendulums under discussion with that of a sidereal clock is about 35 sec. This is connected with the time of vibration by the equation

$$s = \frac{c}{2c - 1}$$

If $c = 35$ sec., $s = 0{\cdot}507$ sec. approximately.

On the front of the flash-box there is a porcelain scale, graduated into divisions of 3 millimetres. By observing the reflection of this scale in the pendulum mirror and noting how many divisions pass over the central wire of the telescope as the pendulum vibrates, the amplitude of the vibration is determined, when the distance between the mirror and the scale is known. A convenient distance is about 2 metres and a convenient initial amplitude (semi-arc) of vibration is from 12 minutes to 20 minutes.

Besides the pendulum apparatus the equipment includes a clock with a half seconds pendulum, specially designed for portability. It has a convenient arrangement whereby the pendulum can be lifted from its bearings and clamped to the back of the case, so that it need not be taken off for a journey.

The clock.

The pendulum, made by Riefler of Munich, is of invar.

The break-circuit arrangement consists of a light lever fixed to one side of the clock case, which is lifted by a short arm on the pendulum as it approaches the end of its swing in that direction. The lever is adjustable so that the circuit may be broken for a longer or shorter fraction of a second at will.

The clock, made by Messrs. Strasser and Rohde of Glasshütte, is known as S.R. 238. This clock was not the only one used for timing the pendulums. Both at Kew and at Greenwich the standard clocks of the observatories were also connected to the flash-box, so that alternate observations could be made on each pendulum. In this paper the clock at Kew is called "Morrison 8702" and that at Greenwich "Sidereal Standard" or "S.S". Two break-circuit chronometers were most generously lent by Messrs. T. Mercer & Sons and by Mr. V. Kullberg respectively at a time when it was feared that S.R. 238 would not be ready.

That lent by Messrs. Mercer & Sons was used at Kew for two sets of observations.

The equipment includes two pairs of centigrade thermometers for the determination of the temperature inside the pendulum cover. The same pair was used both at Kew and at Greenwich, namely No. 105368 and No. 105369 by Negretti and Zambra.

Thermometers.

The degrees are divided on the scale into fifths, and they were read to fiftieths by estimation. The corrections of these thermometers were determined at the National Physical Laboratory both before and after the pendulum observations.

A barometer and hygrometer were lent by the National Physical Laboratory.

THE CORRECTIONS TO THE OBSERVED TIME OF VIBRATION.

The corrections are five in number, viz:—

1. Reduction to a vacuum.
2. " a temperature of 0° C.
3. " an infinitely small arc.
4. " sidereal seconds.
5. " a rigid pillar and stand.

The reduction to a vacuum, or correction for atmospheric density, is given by the expression

Reduction to a vacuum.

$$-\frac{k'(B+b)\left(1-\frac{3}{8}\frac{e}{B}\right)}{760+2{\cdot}79t}$$

where B = height of barometer in observing room,
b = reading of manometer attached to pendulum cover, (not used in these observations),
e = elastic force of aqueous vapour,
t = temperature inside the pendulum cover in degrees centigrade.
k' = a coefficient depending on the pendulum's shape, surface, etc.

The value of k' was carefully determined at Potsdam by Professor Haasemann. He had the advantage of possessing two complete sets of instruments, and was thus able to swing two pendulums simultaneously, timing both by the same clock, and so arranging the observations, as to cause the mean epochs of observation to coincide. The difference of the times of vibration thus obtained was free from the effect of unsteadiness in the rate of the clock.

From observations of all possible pairs of pendulums, under pressures varying from 350^{mm} to 1180^{mm} of mercury, he obtained equations whence the following results were deduced.

Pendulum 137	k' =	594 ± 2·5
138		572 ± 6·5
139		606 ± 1·0
140		606 ± 1·7
Mean	=	595

In these numbers the unit is the 7th decimal place of a sidereal second.

The observations at Kew for the determination of k' were carried out by Mr. E. G. Constable.

No vacuum chamber had been supplied with the apparatus but one was specially made under Dr. Glazebrook's direction.

As only the one apparatus was available at Kew, consecutive observations of the same pendulum under different pressures had to be made and the clock's rate had to be considered invariable.

Observations were made at pressures of 395^{mm}, 585^{mm} and 775^{mm} and the results were as follows :—

Pendulum 137	k' =	605
138		591
139		621
140		603
Mean	=	605

Dr. Chree, who kindly reduced all the Kew observations, estimates that the error in the value of the constant for a single pendulum may not improbably amount to 2 or 3 per cent.

The Kew and Potsdam sets of values therefore agree as well as could be expected.

In the reduction of the pendulum observations, which follow, the Potsdam values have alone been used. This is due to the circumstance that the Kew observations were made later and were not available when the computations were being carried out.

No appreciable effect on the difference between the times of vibration of a pendulum at Kew and Greenwich respectively would be produced by a change of 10 per cent in k', whereas here the difference between the means of the two sets is but 1·7 per cent.

The reduction to 0° Centigrade is sufficiently represented by the simple expression

Reduction to 0° Temp. $$-kt$$

where t is the temperature of the pendulum during the observation and k a factor depending on its coefficient of expansion.

Determinations of k were made both at Potsdam and at Kew. At the former place Professor Haasemann again took advantage of his second apparatus, by comparing the time of vibration of each of the pendulums at different temperatures, with that of a reference pendulum which was swinging in an adjoining room where the temperature was nearly uniform. As before, the same clock was used for both pendulums and thus the results were freed from the effects of variable clock rate.

At Potsdam the pendulums were swung in a special case or chamber in which the temperature was artificially raised; at Kew the whole room in which the observations were made was heated.

At both places the pendulums were swung in air at the natural pressure.

At Potsdam observations were made at 3°C and 44°C approximately; at Kew the temperatures were 7°C, 20°C and 35°C.

The resulting values of k were as follows:—

		Potsdam	Kew
Pendulum	137	49·2 ± 0·1	48·9
,,	138	48·9 ± 0·2	50·8
,,	139	49·1 ± 0·2	48·2
,,	140	48·9 ± 0·1	49·6
	Mean	49·0	49·4

The unit of these numbers is the 7th decimal place of a second of time.

The mean of the readings of two thermometers attached to the stand, the bulb of one being some distance above the middle of the pendulum's stem and that of the other an equal distance below it, was accepted as the temperature of the pendulum.

The thermometers used at Kew were not the same as those used at Potsdam, the latter being considerably smaller than the former; the close agreement between the results given above is some evidence, even if not very conclusive, that during the observations the temperature of the pendulum was well represented by the mean of the two thermometer readings.

Reduction to an infinitely small arc.

The observation of each pendulum does not last longer than an hour and the decrease in arc between the beginning and end is not excessive; the reduction to an infinitely small arc is therefore given with sufficient accuracy by the expression

$$- s \frac{a^2}{16}$$

where s = observed time of vibration
a = mean semi-arc

Reduction to sidereal time.

Since the time of vibration $= 0\overset{s}{.}507$ approximately, the correction to be applied on account of a clock rate of one second per diem is

$$\frac{1}{86400} \times 0\overset{s}{.}507 = 58\overset{s}{.}7 \times 10^{-7}.$$

Reduction to a rigid pillar.

Several methods of determining the correction requisite to reduce the observed time of vibration to what it would have been on a perfectly rigid pillar and stand, have been devised.

In 1818 Kater, in a paper which he communicated to the Royal Society, alluded to the necessity of ascertaining that the stand on which his pendulum was swung was sensibly rigid; and the instrument which he employed for testing this consisted of a vertical rod, supported from below by a thin spring and carrying a moveable weight*. By adjusting the position of the weight the time of vibration of this inverted pendulum was made to coincide with that of the pendulum under observation, on the stand of which it was placed.

If the stand was being drawn to and fro by the swinging pendulum, even to a small extent, a visible vibration would in the course of a few minutes be set up, the amount of this induced vibration being a measure of the flexibility of the stand.

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* A drawing of the instrument is to be found in Plate K.—III, Fig. 4, Vol. V of "*The Account of the Operations of the Great Trigonometrical Survey of India.*"

This idea has been gradually developed, and the apparatus which has been adopted for employment with this equipment is the latest form of device for giving effect to it. It is the invention of Professor R. Schumann of the Prussian Geodetic Institute. The necessary additions to the instrument to enable the method to be applied were made in Potsdam by Messrs. Töpfer & Sohn under Professor Helmert's direction.

The method may be described as follows :—

Two pendulums which vibrate in equal times are suspended on the same stand so that their planes of vibration coincide; both are carefully brought to rest and then one (which will be called the driving pendulum) is set swinging with a considerable amplitude. The rapidity with which the second (which will be called the driven pendulum) takes up the oscillation from the first is a measure of the flexibility of the pillar and stand; the correction to be applied to the time of vibration is deduced from the results of the observation. In order to shield the driven pendulum from the influence of the air set in motion by the driving pendulum a screen is placed between them.

By a theoretical analysis Professor Schumann shows that for a moderate time from the commencement of the oscillation (with these pendulums about 30 minutes), the ratio of the amplitude of the two pendulums increases as the time, the expression being

$$\frac{\phi}{\psi} = \frac{dl}{2l}\sqrt{\frac{g}{l}} \times t$$

where ϕ = amplitude of driven pendulum } at time t
ψ = " driving " } at time t
dl = the small virtual increase in the length of the driving pendulum caused by the flexure of the stand.
l = the length of the pendulum.

It is thus possible with a suitable apparatus to make observations whence dl can be deduced, and thence immediately the increase in the time of the pendulum's vibration due to the flexure of the stand.

Equality in the vibration periods of the two pendulums is one of the necessary conditions, and in practice it is found convenient to use as the driver an auxiliary pendulum, heavier than those of the original set of four and with an adjustable bob. The extra weight is to increase the effect on the driven pendulum and thus render it easier to measure, and the adjustability is to enable it to be used with any of the four invariable pendulums, or indeed with any pendulum whose period is about half a second.

In order to allow of the simultaneous suspension of two pendulums a strong bracket was fitted to the head of the stand, bearing agate planes for the reception of the driven pendulum: means of raising and lowering the pendulum without jarring its edges were provided. When both pendulums are suspended their knife-edges are in the same horizontal plane, parallel to each other and about 3 inches apart.

Fixed to the head of the driving pendulum is an arm, equal in length to this space, which carries at its end a vertical mirror; thus when this pendulum is resting on the central agate plane and the driven pendulum on the bracket their two mirrors are side by side.

The observation consists of simultaneously measuring the amplitudes of the oscillations of the two pendulums. This is done by observing the reflections of the scale fixed to the front of the flash-box. As the amplitudes of the oscillations never exceed 2°, and as their ratio only is required, it is sufficiently accurate to use the scale readings instead of computing the angles.

The observation proceeds as follows :—

When the driven pendulum has been carefully brought to rest in its natural position, the driver is set swinging through a suitable arc: the time at which the oscillation begins is noted and two minutes are allowed to elapse before the observations commence. During the third minute the amplitude of the driver is first noted then that of the driven and then that of the driver again; thus the amplitudes at a common epoch, 2½ minutes from the start, are measured: the fourth minute is allowed to pass, but during the fifth similar readings are made, and so on until eight sets have been recorded.

Eight values of the ratio $\frac{\phi}{\psi}$ have now been obtained, each of which would give a value of dl, but the expression connecting these quantities is based on the hypothesis that the driven pendulum is at perfect rest when the driver begins to oscillate, a condition which may not be satisfied. Prof. Schumann therefore puts $\frac{\phi}{\psi} = C + Dt$

$$\text{where } D = \frac{dl}{2l}\sqrt{\frac{g}{l}}$$

Hence, combining any two of the observations we have

$$\frac{\phi_2}{\psi_2} - \frac{\phi_1}{\psi_1} = \frac{dl}{2l}\sqrt{\frac{g}{l}} \times (t_2 - t_1)$$

$$\text{and} \quad dl = \frac{\left(\frac{\phi_2}{\psi_2} - \frac{\phi_1}{\psi_1}\right)}{t_2 - t_1} \times 2l\sqrt{\frac{l}{g}}$$

or, converting into terms of s the time of vibration common to both pendulums

$$dl = \frac{\left(\frac{\phi_2}{\psi_2} - \frac{\phi_1}{\psi_1}\right)}{t_2 - t_1} \times 2g \times \frac{s^3}{\pi^3}.$$

It is more convenient to find the increase in the time of vibration due to flexure than the virtual increase in the length of the pendulum,

$$\text{and as} \quad \frac{ds}{dl} = \frac{1}{2}\frac{\pi}{\sqrt{gl}}$$

$$\text{we have } ds = \frac{\left(\frac{\phi_2}{\psi_2} - \frac{\phi_1}{\psi_1}\right)}{t_2 - t_1} \times \frac{s^2}{\pi}.$$

The extent to which the pillar yields is proportional to the horizontal pull of the knife-edge on the agate plane; therefore to obtain the quantity appropriate to the invariable pendulum, ds must be multiplied by a factor equal to the ratio of the moments of the invariable and auxiliary pendulums about their knife-edges. An empirical factor depending on the individual peculiarities of each pendulum,—difference in knife-edge etc.— was also sought for, but it was found that for pendulums of this form none is necessary.

The moments of the pendulums were not known but their ratio was determined by the following simple method: the pendulums, suspended as for the flexure observation, were brought to rest and readings of the reflected scales were taken with the telescope and recorded. A thread was then tied lightly round the stems of the pendulums so as to deflect them inwards from the vertical. If the pendulums be then brought to rest, and if the thread by which they are tied be horizontal, the angles through which they have respectively been deflected are in the inverse ratio of the moments about the points of suspension. If the observation of the reflected scales be now repeated the differences between the first and second sets of readings are measures of the angles of deflection, and the inverse ratio of these differences is equal to the required ratio of the moments. By a few repetitions of this process a sufficiently accurate value of the moment ratio can be obtained.

The four pendulums are so similar that in practice it is unnecessary to determine the flexure correction for each separately. The auxiliary pendulum was adjusted to swing isochronously with No. 137 and the latter has always been used for the flexure observation. The ratio of the moments of these two pendulums is 0·533.

The correction to the time of vibration of one of the invariable pendulums when swinging on the stand designed by Colonel von Sterneck—the stand being firmly clamped to a granite slab and the slab cemented to a solid masonry pillar some 20 inches high—is found to be about 38×10^{-7}. It varies slightly according to the tightness of the clamping and the quality of the pillar. 29×10^{-7} and 60×10^{-7} are the extreme values that have so far been found with this apparatus.

The probable error of a single determination is less than $\pm 1 \times 10^{-7}$, and that of the mean of four independent measures will not be larger than the probable error of other corrections.

The following is a specimen of the record of an observation for flexure and of the computation of the correction:—

Observation for Flexure.

Kew, October 16th, 1903. Observer E. G. Constable.

Auxiliary Pendulum started at $36^m\ 20^s$								
No.	Pendulum	Time		Scale Readings		Amplitude	Mean Amplitude	Ratio
		From	To	Above	Below			
1	Auxy: 137 Auxy:	m s 38 20	m s 39 20	14·3 0·2 14·3	14·2 0·0 14·1	28·5 0·2 28·4	28·45 0·2	·0070
2	Auxy: 137 Auxy:	40 20	41 20	14·0 0·3 14·1	13·8 0·2 13·7	27·8 0·5 27·8	27·8 0·5	·0180
3	Auxy: 137 Auxy:	42 20	43 20	14·0 0·45 13·9	13·7 0·4 13·6	27·7 0·85 27·5	27·6 0·85	·0308
4	Auxy: 137 Auxy:	44 20	45 20	13·7 0·55 13·7	13·4 0·5 13·4	27·1 1·05 27·1	27·1 1·05	·0387
5	Auxy: 137 Auxy:	46 20	47 20	13·5 0·7 13·5	13·2 0·6 13·2	26·7 1·3 26·7	26·7 1·3	·0487
6	Auxy: 137 Auxy:	48 20	49 20	13·3 0·8 13·2	13·1 0·8 13·0	26·4 1·6 26·2	26·3 1·6	·0608
7	Auxy: 137 Auxy:	50 20	51 20	13·0 0·9 13·0	12·8 0·95 12·0	25·8 1·85 25·8	25·8 1·85	·0717
8	Auxy: 137 Auxy:	52 20	53 20	12·8 1·0 12·8	12·6 1·0 12·5	25·4 2·0 25·3	25·35 2·0	·0789

Computation of Flexure Correction.

Numbers of the Observations	Difference of Ratios	Factor*	Flexure Correction
5–1	·0417	909×10^{-7}	$37·9 \times 10^{-7}$
6–2	·0428	"	38·9
7–3	·0409	"	37·2
8–4	·0402	"	36·5
		Mean ...	$37·6 \times 10^{-7}$

The coincidence observation.

For the determination of the value of g at any station the programme of observation of each pendulum consists of observing two series of 10 consecutive coincidences each, with an interval of 50 coincidences between the last coincidence of the first series and the first of the second series.

Ten values of a sixty-coincidence interval are thus obtained, from the mean of which a value of the time of vibration can be derived with a probable error not greater than that of the corrections for temperature flexure, etc.

Each pendulum was swung twice in 24 hours, intervals of 12 hours separating the swings, and it was assumed that the mean rate of the clock during the swings was equal to that deduced from star observations made at the same hour each evening.

The observations were usually made from 9 a.m. to 1 p.m. and from 9 p.m. to 1 a.m. the mean of the two constituting a determination of the time of vibration: a single observation was not considered of any value.

A copy of the record of an observation is given as an example.

Station Greenwich.

Date, 24th October 1903. Clock, S. R. 238. Pendulum 140. Observer E.G. Constable.

Time	Barometer		Hygrometer		Arc		Pendulum Thermometers	
	h	t	Dry	Wet	Above	Below	Upper No. 105368	Lower No. 105369
h m	in.	°	°	°	d	d	°	°
10—10	29·727	48·6 F	48·4 F	45·4 F	5·7	5·7	9·85 C	9·90 C
30	·728	48·7	·4	·4	4·7	4·7	·85	·90
59	·726	48·7	·4	·5	3·9	3·9	·85	·90
MEANS ...	**29·727**	**48·7**	**48·4**	**45·4**	**4·8**	**4·8**	**9·85**	**9·90**

* Factor $= \dfrac{s^2}{\pi(t_2 - t_1)} \times \dfrac{m\,s}{m'\,s'} = \dfrac{(0·507)^2}{3·1416 \times 480} \times 0·533 = 0·0000909.$ $t_2 - t_1 = 8$ minutes.

Coincidences.

No.	Time	No.	Time	Difference	Remarks
	h m s		h m s	m s	
1	10 13 29·5	61	10 51 38·0	38 8·5	
2	14 7·8	62	52 16·2	8·4	
3	45·6	63	54·2	8·6	
4	15 24·0	64	53 32·5	8·5	
5	16 2·0	65	54 10·5	8·5	
6	40·4	66	48·8	8·4	
7	17 18·3	67	55 26·9	8·6	
8	56·5	68	56 5·0	8·5	
9	18 34·6	69	43·1	8·5	
10	19 13·0	70	57 21·3	8·3	
11	50·8		MEAN ...	38 8·48	
			= Coincidence interval × 60		

DESCRIPTION OF STATIONS.

At Kew the pendulums were swung in the north room of the small house which lies to the west of the main building.

The pendulums oscillated in the plane of the prime vertical approximately, the shape of the room not permitting of their being swung in the meridian. This room had not before been used for pendulum observations. The rooms in the basement of the main building, which had been occupied by the various observers from 1864 to 1900, now contain the seismograph and are no longer available.

The new station is 100 feet 6 inches west of, 5 inches north of, and 6 feet 4 inches higher than that occupied by Mr. Constable in 1888 and by Mr. G. R. Putnam in 1900.

The co-ordinates of the new station are—

Latitude north	...	51° 28′ 6″.
Longitude west	...	0 18 48.
Height above mean sea level		23 feet.

At Greenwich the station was the same as that occupied by Colonel von Sterneck, Mr. Putnam, Mr. Hollis and others. It is situated in the record room about 20 yards to the east of the prime meridian.

The pendulums oscillated in the plane of the meridian.

The co-ordinates of the station are:—

Latitude north	...	51° 28′ 38″
Longitude east	...	0 0 1
Height above mean sea level	...	155 feet.

Time signals were sent telegraphically every day from Greenwich Observatory to Kew at 10 a.m., and 1 p.m., and recorded on a chronograph at both places, so that the time of the signal in terms of the standard clock at each place could be read off.

Clock rates at Kew.

The true sidereal time at which the signal was sent out from Greenwich was communicated by the Astronomer Royal as soon as the star observations had been reduced, and thus the error of the Kew standard clock (French) was ascertained.

Comparisons between "French" and the clocks used for the pendulum observations, viz:—Morrison 8702, S. R. 238 and Chronometer Mercer, were made by the method of coincidences using the comparing Chronometer Molyneux. These comparisons were made, by Mr. E. G. Constable, twice a day, soon after the time signals had been received from Greenwich.

For each night on which pendulum observations were made at Greenwich, the error of the sidereal standard clock as derived from the star observations, was furnished by the Astronomer Royal.

Clock rates at Greenwich.

S. R. 238 was compared chronographically with the Sidereal Standard several times in the 24 hours and its daily rate was deduced from the results.

The Astronomer Royal kindly lent a very convenient chronograph for this purpose, and gave a permanent connection with the S.S. Clock, so that comparisons could be made at any time.

The following table shows the finally adopted clock rates on sidereal time for each period of 24 hours:—

Table I.

Station	From	To	Rate in 24 hours; + = gaining; − = losing.			
			Morrison 8702	Chronometer Mercer	S.S.	S. R. 238
			s	s	s	s
Kew ...	2 p.m. June 22	2 p.m. June 23	− 0·30			
	„ 23	„ 24	− 0·32			
	„ 24	„ 25	− 0·25			
Kew ...	2 p.m. Octr. 14	2 p.m. Octr. 15	+ 1·06	+ 1·53		
	„ 15	„ 16	+ 1·05	+ 1·11		
Greenwich ...	8 p.m. Octr. 20	8 p.m. Octr. 21			− 0·06	− 0·86
	„ 21	„ 22			+ 0·02	− 0·82
	„ 22	„ 23			− 0·07	− 0·89
	„ 23	„ 24			− 0·02	− 0·87
Kew ...	2 p.m. Octr. 27	2 p.m. Octr. 28	+ 0·85			− 4·90
	„ 28	„ 29	+ 1·00			− 4·85
	„ 29	„ 30	+ 0·80			− 5·00
	„ 30	„ 31	+ 0·80			− 5·25

N.B.—Between June and October the clock Morrison 8702 underwent some alterations.

At Kew the extreme recorded temperatures inside the pendulum cover during a visit (3 to 5 days) differed by 2°·85 C.

Temperature conditions.

The extreme range during the observation of a set of pendulums (4 to 5 hours) was 1°·54 C; and the average 0°·69 C. This change was almost invariably an increase of temperature with the progress of the observation, occasionally it was fluctuating in character but usually fairly regular.

The extreme range during the observation of one pendulum (about 1 hour) was 0°·25 C and the average 0°·07 C, generally, but not invariably, an increase.

At Greenwich the extreme recorded temperatures during the visit differed by 2°·12 C. The extreme range during a set of pendulums was 0°·49 C with an average of 0°·21 C, and the greatest range during the observation of one pendulum was 0°·25 C with an average of 0°·06 C. The superiority of the temperature conditions at Greenwich over those at Kew was due partly to the use of electric light in place of gas, and partly to the fact that the room was larger.

The results of the observations.

The results of the observations together with the reductions are exhibited in Table II.

In the column headed "observer" the initial B denotes Major S. G. Burrard, R.E., C denotes Mr. E. G. Constable and L. C. Major G. P. Lenox Conyngham, R.E.

A word of explanation as to the clocks used and the long interval separating the first observations at Kew from the remainder is called for.

In June 1903 when the observers arrived at Kew and wished to begin work, the clock (S.R.238) which had been ordered as part of the equipment had not been received from the makers, and for the first set of observations at Kew, Morrison 8702 was employed. While these observations were in progress the missing clock arrived, and when the observers moved to Greenwich they took it with them and erected it.

Two series of observations, one at Greenwich and one at Kew, were made with the aid of this clock, between June 29 and July 9, but were found, when reduced, to give very discordant and unsatisfactory results. Irregular clock rate seemed to be the source of evil and the clock was, at the makers' request, sent back for examination.

To reject all the observations made with this clock was the only course open. The Secretary of State for India was asked to sanction the repetition of the work and in October a new series was commenced. On this occasion it was determined, as a precaution, to supplement the observations by S.R.238 with separate timings of the pendulums by the clocks of the observatories, the use of which was kindly allowed by the Director of the National Physical Laboratory and the Astronomer Royal respectively. But again when the observers wished to begin, S. R. 238 had not arrived. Being unwilling to rely on one clock only they then sought the loan of a break circuit chronometer and both Messrs. Mercer & Co. and Messrs. Kulberg & Co. came forward in the most generous way. The observations at Kew from October 14th to 16th were made with the clock Morrison and the Chronometer Mercer, but as S.R.238 arrived on the 15th it was taken to Greenwich and used both there and on the return visit to Kew.

Early in October Major Burrard had to embark for India, so the observations of the second part of the work were made by Mr. Constable and Major Lenox Conyngham.

Table II. Pendulum Observations at Kew.

Date	Time	Observer	Pendulum	Order of Obsn.	Coincidence Interval in Clock seconds	Mean Semi-Arc	Corrected Mean Temperature	Density of Air	Time of Vibration uncorrected	Corrections on account of Clock Rate	Arc	Temper-ature	Density of Air	Flexure	Time of Vibration corrected
1903					s	′	°		s						s
June 22	Night	C	137	1	37·046	9	14·90	·950	0·5068407	+ 18	− 2	− 730	− 564	− 31	0·5067098
"	"	B	138	2	37·795	7	15·40	·948	·5070830	18	1	755	542	31	9519
"	"	L.C.	139	3	37·556	8	15·68	·947	·5067465	18	2	768	574	31	6108
"	"	L.C.	140	4	37·978	7	15·85	·947	·5066706	18	1	777	574	31	5341
" 23	Day	L.C.	137	4	37·031	9	15·84	·943	0·5068435	18	2	776	560	31	7084
"	"	L.C.	138	3	35·803	9	15·37	·945	·5070815	18	2	753	541	31	9506
"	"	C	139	2	37·581	8	14·93	·949	·5067418	18	2	732	575	31	6096
"	"	B	140	1	38·009	7	14·30	·951	·5066652	18	1	701	576	31	5361
												Mean Pendulum			·5067014
June 23	Night	B	137	1	37·040	8	15·89	·942	0·5068418	+ 19	− 2	− 779	− 560	− 31	0·5067065
"	"	C	138	2	35·788	8	16·39	·941	·5070848	19	2	803	538	31	9493
"	"	L.C.	139	3	37·541	8	16·39	·939	·5067492	19	2	803	569	31	6106
"	"	L.C.	140	4	37·969	7	16·34	·939	·5066722	19	1	801	569	31	5339
" 24	Day	L.C.	137	4	37·014	11	16·59	·936	0·5068467	19	3	813	556	31	7083
"	"	C	138	3	35·788	8	16·05	·938	·5070845	19	2	786	537	31	9508
"	"	C	139	2	37·549	8	15·84	·941	·5067477	19	2	776	570	31	6117
"	"	B	140	1	37·983	6	15·52	·943	·5066699	19	1	760	571	31	5355
												Mean Pendulum			·5067008
June 24	Night	B	137	1	37·014	11	16·49	·939	0·5068467	+ 15	− 3	− 808	− 558	− 31	0·5067082
"	"	C	138	2	35·775	10	16·39	·939	·5070873	15	2	803	537	31	9515
"	"	L.C.	139	3	37·530	9	16·49	·941	·5067510	15	2	808	570	31	6114
"	"	L.C.	140	4	37·963	8	16·41	·941	·5066734	15	2	804	570	31	5342
" 25	Day	L.C.	137	4	37·021	9	16·23	·943	0·5068456	15	2	795	560	31	7083
"	"	C	138	3	35·788	9	15·82	·945	·5070847	15	2	775	541	31	9513
"	"	C	139	2	37·543	9	15·82	·946	·5067489	15	2	775	573	31	6123
"	"	B	140	1	37·975	8	15·88	·944	·5066712	15	2	778	572	31	5344
												Mean Pendulum			·5067015
												General Mean			·5067012

Table II. Pendulum Observations at Kew.

Date	Time	Observer	Pendulum	Order of Observation	Coincidence Interval: Clock M. 8702	Coincidence Interval: Chron. Mercer	Mean Semi-Arc	Corrected Mean Temperature	Density of Air	Time of Vibration uncorrtd.: Clock Morrison 8702	Time of Vibration uncorrtd.: Chron. Mercer	Corrections on account of: Clock Rate M. 8702	Corrections on account of: Clock Rate Chron. Mercer	Corrections on account of: Arc	Corrections on account of: Temperature	Corrections on account of: Density of Air	Corrections on account of: Flexure	Time of Vibration corrected: Clock Morrison 8702	Time of Vibration corrected: Chron. Mercer	Time of Vibration corrected: Mean
1903					s	s	′	°		s	s							s	s	s
Oct. 14	Night	C	137	1	37·016	37·025	10	14·18	·934	·5068462	·5068447	−62	−90	−3	− 695	− 555	−37	·5067110	·5067067	·5067089
		L. C.	138	3	35·803	35·765	11	14·71	·930	·5070815	·5070892	62	90	3	721	532	37	·5069460	·5069509	·5069485
		C	139	2	37·566	37·531	10	14·45	·933	·5067447	·5067510	62	90	3	708	565	37	·5066072	·5066107	·5066090
		L.C.	140	4	37·973	37·945	13	14·98	·928	·5066715	·5066763	62	90	5	734	562	37	·5065315	·5065335	·5065325
Oct. 15	Day	C	137	1	37·117	37·049	12	13·87	·932	·5068275	·5068402	62	90	4	680	554	37	·5066938	·5067037	·5066988
		L. C.	138	3	35·802	35·788	13	14·25	·933	·5070817	·5070847	62	90	5	698	534	37	·5069481	·5069483	·5069482
		C	139	2	37·564	37·549	11	14·08	·934	·5067450	·5067479	62	90	3	690	566	37	·5066092	·5066093	·5066092
		L.C.	140	4	37·984	37·965	12	14·50	·933	·5066695	·5066729	62	90	4	711	565	37	·5065316	·5065322	·5065319
															Mean Pendulum			·5066973	·5066994	·5066984
Oct. 15	Night	L. C.	137	3	37·052	37·034	11	14·21	·938	·5068397	·5068429	−62	−65	−3	− 696	− 557	−37	·5067042	·5067071	·5067057
		C	138	1	35·804	35·820	11	14·01	·939	·5070812	·5070781	62	65	3	686	537	37	·5069487	·5069453	·5069470
		L.C.	139	4	37·574	37·549	12	14·23	·939	·5067432	·5067478	62	65	4	697	569	37	·5066063	·5066106	·5066084
		C	140	2	37·993	37·979	11	14·22	·939	·5066680	·5066703	62	65	3	697	569	37	·5065312	·5065332	·5065322
Oct. 16	Day	L. C.	137	3	37·075	37·070	11	12·98	·944	·5068353	·5068360	62	65	3	636	561	37	·5067054	·5067058	·5067056
		C	138	1	35·838	35·847	11	12·43	·947	·5070746	·5070728	62	65	3	609	542	37	·5069493	·5069472	·5069482
		L. C.	139	4	37·597	37·582	14	13·29	·941	·5067391	·5067417	62	65	5	651	570	37	·5066066	·5066089	·5066078
		C	140	2	38·035	38·016	12	12·73	·946	·5066605	·5066638	62	65	4	624	573	37	·5065305	·5065335	·5065320
															Mean Pendulum			·5066978	·5066990	·5066984
															General Mean			·5066976	·5066992	·5066984

Table II. Pendulum Observations at Greenwich.

Date	Time	Observer	Pendulum	Order of Observation	Coincidence Interval: Clock S. S.	Coincidence Interval: Clock S. R. 238	Mean Semi-Arc	Corrected Mean Temperature	Density of Air	Time of Vibration uncorrtd.: Clock S. S.	Time of Vibration uncorrtd.: Clock S. R. 238	Corrections on account of: Clock Rate S. S.	Clock Rate S. R. 238	Arc	Temperature	Density of Air	Flexure	Time of Vibration corrected: Clock S. S.	Clock S. R. 238	Mean
1903					s	s	′	°		s	s							s	s	s
Oct. 20	Night	C	137	1	37·120	37·139	10	11·54	·948	·5068270	·5068233	+ 4	+ 50	− 3	− 565	− 563	− 39	·5067104	·5067113	·5067109
		L. C.	138	3	35·874	35·892	14	11·58	·948	·5070673	·5070636	4	50	5	567	542	39	·5069524	·5069533	·5069528
		C	139	2	37·635	37·663	10	11·52	·948	·5067322	·5067272	4	50	3	564	574	39	·5066146	·5066142	·5066144
		L. C.	140	4	38·062	38·080	13	11·63	·947	·5066558	·5066526	4	50	5	570	574	39	·5065374	·5065388	·5065381
Oct. 21	Day	C	137	1	37·117	37·137	11	11·64	·947	·5068275	·5068237	4	50	3	570	563	39	·5067104	·5067112	·5067108
		C	138	3	35·868	35·899	11	11·75	·946	·5070685	·5070623	4	50	3	576	541	39	·5069530	·5069514	·5069522
		C	139	2	37·631	37·666	12	11·72	·946	·5067329	·5067267	4	50	4	574	573	39	·5066143	·5066127	·5066135
		C	140	4	38·058	38·084	12	11·75	·946	·5066563	·5066518	4	50	4	576	573	39	·5065375	·5065376	·5065376
																Mean Pendulum		·5067038	·5067038	·5067038
Oct. 21	Night	L. C.	137	3	37·114	37·148	15	11·36	·947	·5068279	·5068217	− 1	+ 48	− 6	− 556	− 563	− 39	·5067114	·5067101	·5067107
		L. C.	138	1	35·877	35·911	14	11·41	·947	·5070665	·5070599	1	48	5	559	542	39	·5069519	·5069502	·5069511
		L. C.	139	4	37·637	37·665	16	11·31	·948	·5067318	·5067268	1	48	7	554	574	39	·5066143	·5066142	·5066142
		L. C.	140	2	38·052	38·097	13	11·40	·947	·5066575	·5066495	1	48	5	558	574	39	·5065398	·5065367	·5065383
Oct. 22	Day	C	137	3	37·125	37·153	12	11·24	·939	·5068259	·5068208	1	48	4	551	558	39	·5067106	·5067104	·5067105
		C	138	1	35·873	35·900	10	11·04	·941	·5070675	·5070621	1	48	3	541	538	39	·5069553	·5069548	·5069551
		L. C.	139	4	37·639	37·675	13	11·41	·936	·5067315	·5067249	1	48	5	559	567	39	·5066144	·5066127	·5066135
		C	140	2	38·080	38·102	12	11·12	·939	·5066526	·5066487	1	48	4	545	569	39	·5065368	·5065378	·5065373
																Mean Pendulum		·5067043	·5067034	·5067038
Oct. 22	Night	C	137	2	37·127	37·164	12	11·12	·938	·5068257	·5068188	+ 4	+ 52	− 4	− 545	− 557	− 39	·5067116	·5067095	·5067106
		L. C.	138	4	35·884	35·906	14	11·15	·939	·5070653	·5070608	4	52	5	546	537	39	·5069530	·5069533	·5069531
		C	139	1	37·651	37·683	9	11·07	·938	·5067295	·5067235	4	52	2	542	568	39	·5066148	·5066136	·5066142
		L. C.	140	3	38·075	38·098	14	11·11	·939	·5066535	·5066493	4	52	5	544	569	39	·5065382	·5065388	·5065385
Oct. 23	Day	C	137	2	37·148	37·174	12	10·57	·944	·5068216	·5068168	4	52	4	518	561	39	·5067098	·5067098	·5067098
		L. C.	138	4	35·894	35·919	15	10·71	·942	·5070632	·5070583	4	52	6	526	539	39	·5069527	·5069526	·5069526
		C	139	1	37·659	37·693	12	10·47	·944	5067279	·5067218	4	52	4	513	572	39	·5066155	·5066142	·5066149
		C	140	3	38·091	38·119	12	10·67	·942	·5066506	·5066457	4	52	4	523	571	39	·5065373	·5065372	·5065373
																Mean Pendulum		·5067041	·5067036	·5067039

Table II. Pendulum Observations at Greenwich.

Date	Time	Observer	Pendulum	Order of Observation	Coincidence Interval		Mean Semi-Arc	Corrected Mean Temperature	Density of Air	Time of Vibration uncorrtd.		Corrections on account of						Time of Vibration corrected		
					Clock S. S.	Clock S. R. 238				Clock S. S.	Clock S. R. 238	Clock Rate		Arc	Temperature	Density of Air	Flexure	Clock S. S.	Clock S. R. 238	Mean
												S. S.	S. R. 238							
					s	s	′	°		s	s							s	s	s
1903		L. C.	137	4	37·141	37·167	12	10·52	·954	·5068230	·5068183	+ 1	+ 51	− 4	− 515	− 567	− 39	·5067106	·5067109	·5067107
Oct. 23	Night	C	138	2	35·889	35·917	13	10·72	·949	·5070643	·5070586	1	51	5	526	543	39	·5069532	·5069525	·5069529
		L. C.	139	3	37·657	37·688	14	10·58	·952	·5067282	·5067227	1	51	5	518	577	39	·5066144	·5066139	·5066141
		C	140	1	38·085	38·117	13	10·66	·949	·5066516	·5066460	1	51	5	522	575	39	·5065376	·5065370	·5065373
Oct. 24	Day	L. C.	137	4	37·150	37·187	15	10·22	·952	·5068215	·5068145	1	51	6	501	565	39	·5067105	·5067085	·5067095
		C	138	2	35·917	35·950	12	9·88	·958	·5070587	·5070521	1	51	4	484	548	39	·5069513	·5069497	·5069505
		C	139	3	37·669	37·710	14	10·01	·954	·5067261	·5067187	1	51	5	490	578	39	·5066150	·5066126	·5066138
		C	140	1	38·154	38·141	11	9·73	·958	·5066393	·5066415	1	51	3	477	581	39	·5065264	·5065366	·5065330
																Mean Pendulum		·5067028	·5067027	·5067027
																General Mean		·5067037	·5067034	·5067036

Table II. Pendulum Observations at Kew.

Date	Time	Observer	Pendulum	Order of Observation	Coincidence Interval: Clock S. R. 238	Coincidence Interval: Clock Morrison 8702	Mean Semi-Arc	Corrected Mean Temperature	Density of Air	Time of Vibration uncorrtd.: Clock S. R. 238	Time of Vibration uncorrtd.: Clock Morrison 8702	Corrections on account of Clock Rate: S. R. 238	Corrections on account of Clock Rate: M. 8702	Corrections: Arc	Corrections: Temperature	Corrections: Density of Air	Corrections: Flexure	Time of Vibration corrected: S. R. 238	Time of Vibration corrected: Morrison 8702	Time of Vibration corrected: Mean
1903					s	s	′	°		s	s							s	s	s
Oct. 27	Night	C	137	1	37·275	37·095	11	12·62	·923	·5067981	·5068316	+288	−50	−3	−618	− 548	−45	·5067055	·5067052	·5067054
		L. C.	138	3	35·998	35·828	14	13·60	·920	·5070427	·5060765	288	50	5	666	526	45	·5069473	·5069473	·5069473
		C	139	2	37·789	37·598	12	12·87	·922	·5067045	·5067388	288	50	4	631	559	45	·5066094	·5066099	·5066096
		L. C.	140	4	38·185	37·998	15	13·73	·918	·5066340	·5066670	288	50	6	673	556	45	·5065348	·5065340	·5065344
Oct. 28	Day	C	137	1	37·258	37·042	11	12·84	·921	·5068012	·5068415	288	50	3	629	547	45	·5067076	·5067141	·5067109
		L. C.	138	3	36·004	35·831	13	13·23	·926	·5070415	·5070759	288	50	5	648	530	45	·5069475	·5069481	·5069478
		C	139	2	37·780	37·590	11	12·97	·925	·5067059	·5067405	288	50	3	636	561	45	·5066102	·5066110	·5066106
		L. C.	140	4	38·193	38·003	14	13·38	·926	·5066325	·5066661	288	50	5	656	561	45	·5065346	·5065344	·5065345
																	Mean Pendulum	·5066996	·5067005	·5067001
Oct. 28	Night	L. C.	137	3	37·237	37·060	14	13·42	·932	·5068051	·5068381	+285	−59	−5	−658	− 554	−45	·5067074	·5067060	·5067067
		C	138	1	36·009	35·835	13	13·02	·935	·5070407	·5070753	285	59	5	638	535	45	·5069469	·5069471	·5069470
		L. C.	139	4	37·760	37·580	15	13·54	·931	·5067097	·5067422	285	59	6	663	561	45	·5066104	·5066085	·5066095
		C	140	2	38·201	38·007	14	13·23	·935	·5066310	·5066653	285	59	5	648	567	45	·5065330	·5065329	·5065329
Oct. 29	Day	L. C.	137	3	37·257	37·066	14	13·22	·936	·5068013	·5068372	285	59	5	648	556	45	·5067044	·5067059	·5067052
		C	138	1	36·027	35·857	12	12·48	·941	·5070368	·5070708	285	59	4	612	538	45	·5069454	·5069450	·5069452
		L. C.	139	4	37·784	37·577	17	13·32	·935	·5067052	·5067428	285	59	8	653	567	45	·5066064	·5066096	·5066080
		C	140	2	38·221	38·020	12	12·79	·937	·5066277	·5066631	285	59	4	627	568	45	·5065318	·5065328	·5065323
																	Mean Pendulum	·5066982	·5066985	·5066984
Oct. 29	Night	C	137	2	37·237	37·059	14	13·46	936	·5068051	·5068382	+294	−47	−5	−660	− 556	−45	·5067079	·5067069	·5067074
		L. C.	138	4	35·974	35·816	14	14·01	·934	·5070473	·5070788	294	47	5	686	534	45	·5069497	·5069471	·5069484
		C	139	1	37·760	37·574	14	13·38	·937	·5067095	·5067433	294	47	5	656	568	45	·5066115	·5066112	·5066114
		L. C.	140	3	38·184	38·001	12	13·81	·935	·5066341	·5066663	294	47	4	677	567	45	·5065342	·5065323	·5065332
Oct. 30	Day	C	137	2	37·261	37·074	14	12·94	·945	·5068008	·5068356	294	47	5	634	561	45	·5067057	·5067064	·5067061
		L. C.	138	4	35·990	35·823	13	13·44	·944	·5070443	·5070776	294	47	5	659	540	45	·5069488	·5069480	·5069484
		C	139	1	37·780	37·590	14	12·72	·946	·5067060	·5067402	294	47	5	623	573	45	·5066108	·5066109	·5066108
		L. C.	140	3	38·207	38·015	15	13·18	·945	·5066301	·5066640	294	47	6	646	573	45	·5065325	·5065323	·5065324
																	Mean Pendulum	·5067001	·5066994	·5066998

Table II. Pendulum Observations at Kew.

Date	Time	Observer	Pendulum	Order of Observation	Coincidence Interval		Mean Semi-Arc	Corrected Mean Temperature	Density of Air	Time of Vibration uncorrtd.		Corrections on account of						Time of Vibration corrected		
					Clock S. R. 238	Clock Morrison 7802				Clock S. R. 238	Clock Morrison 8702	Clock Rate S. R. 238	Clock Rate M. 8702	Arc	Temperature	Density of Air	Flexure	S. R. 238	Morrison 8702	Mean
1903					s	s	′	°		s	s							s	s	s
Oct. 30	Night	L. C.	137	4	37·239	37·061	14	13·31	·950	·5068049	·5068379	+308	−47	−5	−652	−564	−45	·5067091	·5067066	·5067079
		C	138	2	35·998	35·830	15	13·01	·950	·5070428	·5070762	308	47	6	637	543	45	·5069505	·5069484	·5069494
		L. C.	139	3	37·772	37·589	15	13·21	·950	·5067076	·5067405	308	47	6	647	576	55	·5066110	·5066084	·5066097
		C	140	1	38·204	38·009	15	12·91	·950	·5066307	·5066652	308	47	6	633	576	45	·5065355	·5065345	·5065350
Oct. 31	Day	L. C.	137	4	37·292	37·098	15	11·89	·956	·5067950	·5068309	308	47	6	583	568	45	·5067056	·5067060	·5067058
		C	138	2	36·052	35·870	11	11·30	·960	·5070320	·5070679	308	47	3	554	549	45	·5069477	·5069481	·5069479
		C	139	3	37·832	37·631	12	11·58	·958	·5066967	·5067331	308	47	4	567	581	45	·5066078	·5066087	·5066083
		C	140	1	38·268	38·071	12	11·19	·961	·5066192	·5066541	308	47	4	548	582	45	·5065321	·5065315	·5065318
																Mean Pendulum		·5066999	·5066990	·5066995
																General Mean		·5066995	·5066994	·5066994

In Table III the results obtained in Table II are arranged so as to show the behaviour of the individual pendulums.

Table III.—Time of Vibration.

Kew. *(First Visit).*

Determination A.

Clock	Morrison 8702			
Pendulum	137	138	139	140
	s	s	s	s
June 22 night	0·5067098	0·5069519	0·5066108	0·5065341
„ 23 day	·5067084	·5069506	·5066096	·5065361
Mean ...	·5067091	·5069513	·5066102	·5065351
June 23 night	·5067065	·5069493	·5066106	·5065339
„ 24 day	·5067083	·5069508	·5066117	·5065355
Mean ...	·5067074	·5069500	·5066112	·5065347
June 24 night	·5067082	·5069515	·5066114	·5065342
„ 25 day	·5067083	·5069513	·5066123	·5065344
Mean ...	·5067083	·5069514	·5066118	·5065343
Mean of each Pendulum	·5067083	·5069509	·5066111	·5065347
GENERAL MEAN	s 0·5067012			
Differences from Mean	+ 71	+ 2497	− 901	− 1665

Kew. (*Second Visit*).

Determination B. — ***Determination C.***

Clock	Morrison 8702				Chronometer Mercer			
Pendulum	137	138	139	140	137	138	139	140
Oct. 14 night „ 15 day	s 0·5067110 ·5066938	s 0·5069460 ·5069481	s 0·5066072 ·5066092	s 0·5065315 ·5065316	s 0·5067067 ·5067037	s 0·5069509 ·5069483	s 0·5066107 ·5066093	s 0·5065335 ·5065322
Mean ...	·5067024	·5069471	·5066082	·5065315	·5067052	·5069496	·5066100	·5065329
Oct. 15 night „ 16 day	·5067042 ·5067054	·5069487 ·5069493	·5066063 ·5066066	·5065312 ·5065305	·5067071 ·5067058	·5069453 ·5069472	·5066106 ·5066089	·5065332 ·5065335
Mean ...	·5067048	·5069490	·5066065	·5065309	·5067064	·5069463	·5066097	·5065334
Mean of each Pendulum	·5067036	·5069481	·5066073	·5065312	·5067058	·5069480	·5066099	·5065331
GENERAL MEAN	s 0·5066976				s 0·5066992			
Differences from Mean	+ 60	+ 2505	− 903	− 1664	+ 66	+ 2488	− 893	− 1661

Kew (*Third Visit*).

Determination D. — ***Determination E.***

Clock	S. R. 238				Morrison 8702			
Pendulum	137	138	139	140	137	138	139	140
Oct. 27 night „ 28 day	s 0·5067055 ·5067076	s 0·5069473 ·5069475	s 0·5066094 ·5066102	s 0·5065348 ·5065346	s 0·5067052 ·5067141	s 0·5069473 ·5069481	s 0·5066099 ·5066110	s 0·5065340 ·5065344
Mean ...	·5067066	·5069474	·5066098	·5065347	·5067097	·5069477	·5066104	·5065342
Oct. 28 night „ 29 day	·5067074 ·5067044	·5069469 ·5069454	·5066104 ·5066064	·5065330 ·5065318	·5067060 ·5067059	·5069471 ·5069450	·5066085 ·5066096	·5065329 ·5065328
Mean ...	·5067059	·5069462	·5066084	·5065324	·5067060	·5069460	·5066091	·5065328
Oct. 29 night „ 30 day	·5067079 ·5067057	·5069497 ·5069488	·5066115 ·5066108	·5065342 ·5065325	·5067069 ·5067064	·5069471 ·5069480	·5066112 ·5066109	·5065323 ·5065323
Mean ...	·5067068	·5069493	·5066111	·5065334	·5067066	·5069476	·5066110	·5065323
Oct. 30 night „ 31 day	·5067091 ·5067056	·5069505 ·5069477	·5066110 ·5066078	·5065355 ·5065321	·5067066 ·5067060	·5069484 ·5069481	·5066084 ·5066087	·5065345 ·5065315
Mean ...	·5067074	·5069491	·5066094	·5065338	·5067063	·5069483	·5066085	·5065330
Mean of each Pendulum	·5067067	·5069480	·5066097	·5065336	·5067071	·5069474	·5066098	·5065331
GENERAL MEAN	s 0·5066995				s 0·5066994			
Differences from Mean	+ 72	+ 2485	− 898	− 1659	+ 77	+ 2480	− 896	− 1663

Table III.—Time of Vibration.

Greenwich.

Determination A. *Determination B.*

Clock	Sidereal Standard				S. R. 238			
Pendulum	137	138	139	140	137	138	139	140
	s	s	s	s	s	s	s	s
Oct. 20 night	0·5067104	0·5069524	0·5066146	0·5065374	0·5067113	0·5069533	0·5066142	0·5065388
„ 21 day	·5067104	·5069530	·5066143	·5065375	·5067112	·5069514	·5066127	·5065376
Mean	·5067104	·5069527	·5066145	·5065374	·5067113	·5069523	·5066135	·5065382
Oct. 21 night	·5067114	·5069519	·5066143	·5065398	·5067101	·5069502	·5066142	·5065367
„ 22 day	·5067106	·5069553	·5066144	·5065368	·5067104	·5069548	·5066127	·5065378
Mean	·5067110	·5069536	·5066144	·5065383	·5067102	·5069525	·5066135	·5065372
Oct. 22 night	·5067116	·5069530	·5066148	·5065382	·5067095	·5069533	·5066136	·5065388
„ 23 day	·5067098	·5069527	·5066155	·5065373	·5067098	·5069526	·5066142	·5065372
Mean	·5067107	·5069529	·5066151	·5065378	·5067097	·5069529	·5066139	·5065380
Oct. 23 night	·5067106	·5069532	·5066144	·5065376	·5067109	·5069525	·5066139	·5065370
„ 24 day	·5067105	·5069513	·5066150	·5065294	·5067085	·5069497	·5066126	·5065366
Mean	·5067106	·5069522	·5066147	·5065335	·5067097	·5069511	·5066133	·5065368
Mean of each Pendulum	·5067107	·5069529	·5066147	·5065368	·5067102	·5069522	·5066136	·5065375
GENERAL MEAN	s 0·5067038				s 0·5067034			
Differences from Mean	+ 69	+ 2491	− 891	− 1670	+ 68	+ 2488	− 898	−1659

In the computation of Tables II & III the temperature of the pendulums has been assumed equal to the mean of the readings of the thermometers. This assumption may be legitimate when the temperature of the air is steady, but when the latter is rising or falling the pendulums will unquestionably lag behind the thermometers in taking up the change, and consequently a further correction depending on the temperature gradient, will be required.

This correction may be called either the "lag" correction, or the "dynamical" temperature correction.

No experiments have as yet been made to determine the amount of this correction in the case of these pendulums, but with an almost identical apparatus belonging to the Prussian Geodetic Institute it was found to be $25^s \times 10^{-7}$ for a rate of change of temperature of 1° C. per hour.

To obtain a view of the march of temperature during each of the sets of observations, and of the consequent lag correction, Table IV has been drawn up. In the column headed "mean temperatures" are shown, firstly, the mean of the temperatures of the first two pendulums of a set, and, secondly, that of the last two. (It is to be noted that in Table II, whence the temperatures are taken, the pendulums are entered in numerical order; the order of observation in the set is shown in the column to the right of the distinguishing numbers: thus 137. 3. means that No. 137 was observed third). The sign of the correction is easily understood when it is considered that with a rising temperature the pendulums are cooler than the thermometer readings would lead one to suppose.

Table IV. Showing change of temperature during an observation of the pendulums and the deduced correction on account of the lag of the pendulums on the thermometers.

Station	Date			Time	Mean Temperature	Change	Interval	Correction
				h	°	°	h	
Kew	June	22	night	15·2	15·15 C			
			"	17·8	15·77	+0·62	2·6	+ 6·0
	"	23	day	3·7	14·62			
			"	6·4	15·61	+0·99	2·7	+ 9·2
	"	"	night	15·5	16·14			
			"	17·9	16·37	+0·23	2·4	+ 2·4
	"	24	day	3·5	15·68			
			"	6·3	16·32	+0·64	2·8	+ 5·7
	"	"	night	15·8	16·44			
			"	18·0	16·45	+0·01	2·2	+ 0·1
	"	25	day	3·7	15·85			
			"	5·8	16·03	+0·18	2·1	+ 2·1
							Mean	+ 4·3
				h	°	°	h	
Kew	October	14	night	22·5	14·32			
			"	1·2	14·84	+0·52	2·7	+ 4·8
	"	15	day	11·0	13·98			
			"	13·6	14·38	+0·40	2·6	+ 3·8
	"	"	night	22·5	14·12			
			"	1·2	14·22	+0·10	2·7	+ 0·9
	"	16	day	11·0	12·58			
			"	13·7	13·14	+0·56	2·7	+ 5·2
							Mean	+ 3·7
				h	°	°	h	
Greenwich	October	20	night	23·0	11·53			
			"	1·7	11·61	+0·08	2·7	+0·7
	"	21	day	11·2	11·68			
			"	13·8	11·75	+0·07	2·6	+0·7
	"	"	night	23·7	11·41			
			"	2·2	11·34	−0·07	2·5	−0·7
	"	22	day	11·3	11·08			
			"	14·0	11·33	+0·25	2·7	+2·3
	"	"	night	23·1	11·10			
			"	2·1	11·13	+0·03	3·0	+0·3
	"	23	day	11·4	10·52			
			"	14·1	10·69	+0·17	2·7	+1·5
	"	"	night	23·3	10·69			
			"	2·0	10·55	−0·14	2·7	−1·3
	"	24	day	11·3	9·81			
			"	13·8	10·12	+0·31	2·5	+3·1
							Mean	+0·8
				h	°	°	h	
Kew	October	27	night	23·3	12·75			
			"	2·1	13·67	+0·92	2·8	+8·2
	"	28	day	12·0	12·91			
			"	14·5	13·31	+0·40	2·5	+4·0
	"	"	night	23·6	13·13			
			"	2·1	13·48	+0·35	2·5	+3·5
	"	29	day	12·1	12·64			
			"	14·8	13·27	+0·63	2·7	+5·8
	"	"	night	23·7	13·42			
			"	2·3	13·91	+0·49	2·6	+4·7
	"	30	day	12·0	12·83			
			"	15·5	13·31	+0·48	3·5	+3·4
	"	"	night	23·8	12·96			
			"	2·2	13·26	+0·30	2·4	+3·1
	"	31	day	12·1	11·25			
			"	14·6	11·74	+0·49	2·5	+4·9
							Mean	+4·7

The correction has been assumed to be $25^{s} \times 10^{-7}$ for a change of 1° C. per hour.

Applying the mean corrections for lag found in Table IV to the results given in Table III we obtain the final values of the time of vibration of the mean pendulum at Kew and Greenwich respectively, having 5 values of the former and 2 of the latter.

In Table V these values and their unweighted means are abstracted.

Table V. Times of Vibrations and unweighted means.

Kew.

Date	Clock	Times from Table III	Lag Correction	Corrected Time of Vibration
June 22-25	M. 8702	0^{s}·5067012	+ 4	0^{s}·5067016
October 14-16	M. 8702	·5066976	+ 4	·5066980
	Chronr. Mercer	·5066992	+ 4	·5066996
October 27-31	M. 8702	·5066994	+ 5	·5066999
	S. R. 238	·5066995	+ 5	·5067000
			MEAN	0^{s}·5066998

Greenwich.

Date	Clock	Times from Table III	Lag Correction	Corrected Time of Vibration
October 20-24	S. S.	0^{s}·5067038	+ 1	0^{s}·5067039
	S. R. 238	.5067034	+ 1	·5067035
			MEAN	0^{s}·5067037

As however the results at Kew are discordant it is desirable to weight the individual values before combining them.

Weights.

The differences between the individual pendulums and the mean pendulum, which, on the supposition that the pendulums are invariable, should be constant, afford perhaps the best criterion of the relative weights of different sets of observations.

In order to test the invariability of the pendulums the differences from the mean are arranged in chronological order in Table VI; the mean of results obtained on the same date by different clocks has been entered instead of the individual values, as a discrepancy between simultaneous observations cannot be due to an alteration in a pendulum's length.

Table VI. Differences between individual pendulums and the mean pendulum, arranged chronologically.

Place	Date	137	138	139	140
Kew	June 22-25	+ 71	+ 2497	− 901	− 1665
"	Oct: 14-16	63	2497	898	1663
Greenwich	Oct: 20-24	69	2490	895	1665
Kew	Oct: 27-31	74	2483	897	1661

In the case of No. 138 there seems at first sight to be some evidence of progressive change, but on examining Table VII in which all the sets of differences are given, it will be seen that simultaneous observations occasionally disagree by amounts as large as the variation exhibited by No. 138, and it is therefore as probable that the differences are accidental as that they are due to an alteration in the pendulum's length.

Table VII. Differences between individual pendulums and the mean pendulum.

Station	Determination	137	138	139	140
Kew	A	+ 71	+ 2497	− 901	− 1665
"	B	60	2505	903	1664
"	C	66	2488	893	1661
"	D	72	2485	898	1659
"	E	77	2480	896	1663
Greenwich	A	69	2491	891	1670
"	B	68	2488	898	1659
	Means	69	2491	897	1663

Table VIII. Deduction of weights and formation of general means.

Pendulum	Kew										Greenwich			
	A		B		C		D		E		A		B	
	v	vv	v	vv	v	vv	v	vv	v	vv	v	vv	v	vv
137	2	4	9	81	3	9	3	9	8	64	0	0	1	1
138	6	36	14	196	3	9	6	36	11	121	0	0	3	9
139	4	16	6	36	4	16	1	1	1	1	6	36	1	1
140	2	4	1	1	2	4	4	16	0	0	7	49	4	16
[vv] ...		60		314		38		62		186		85		27
Weight ...		5		1		8		5		2		4		12
Time of Vibration	s 0·5067016		s 0·5066980		s 0·5066996		s 0·5067000		s 0·5066699		s 0·5067039		s 0·5067035	
Weighted Means	s 0·5067001										s 0·5067036			
Difference, Greenwich − Kew	s 0·0000035													

The Accuracy of the Observations.

Behaviour of individual pendulums.

The times of vibration of the mean pendulum at Kew and Greenwich respectively, which are deduced in Table VIII, are the final results of the observations, but it will be of interest to deduce a result from each pendulum separately.

In Table IX the observed times of vibration of each pendulum are combined using the weights deduced in Table VIII, and the differences between the weighted means at Kew and Greenwich are shown. The values of the times of vibration are taken from Tables II & III in which the lag correction has not been applied.

Table IX. Abstract of results by each pendulum and formation of weighted means and their differences.

Station and Determination		137 Time of Vibrn.	137 Weight	138 Time of Vibrn.	138 Weight	139 Time of Vibrn.	139 Weight	140 Time of Vibrn.	140 Weight
KEW	A	s 0·5067083	5	s 0·5069509	5	s 0·5066111	5	s 0·5065347	5
	B	036	1	481	1	073	1	312	1
	C	058	8	480	8	099	8	331	8
	D	067	5	480	5	097	5	336	5
	E	071	2	474	2	098	2	331	2
	Mean	s 0·5067066		s 0·5069486		s 0·5066100		s 0·5065335	
GREENWICH	A	s 0·5067107	1	s 0·5069529	1	s 0·5066147	1	s 0·5065368	1
	B	102	3	522	3	136	3	375	3
	Mean	s 0·5067103		s 0·5069524		s 0·5066139		s 0·5065373	
Difference		0·0000037		0·0000038		0·0000039		0·0000038	
Lag Correction		− 3		− 3		− 3		− 3	
Final Difference		s 0·0000034		s 0·0000035		s 0·0000036		s 0·0000035	

Probable error of corrected time of vibration.

An attempt must now be made to estimate the accuracy of the corrected time of vibration of the mean pendulum. For this purpose Table X has been drawn up shewing the result of each double observation of each pendulum, and the sums of the squares of the residuals, thence the probable error of the corrected time of vibration of each pendulum and of the mean pendulum is deduced.

The result of a double observation, that is of one made by night and one by day, with an interval of twelve hours between them, should be, to a great extent, free from the systematic effects of variation in the rate of the clock, and is therefore more suitable for an investigation of accidental errors than the result of a single observation would be.

The figures for the individual pendulums are taken from Table III and those for the mean pendulum from Table II. The lag correction has not been applied.

Table X. Deduction of probable error.

Station & Determination	Date 1903	137 Mean of day and night observations	138 Mean of day and night observations	139 Mean of day and night observations	140 Mean of day and night observations	Mean Pendulum Mean of day and night observations
Kew A	June 22-23 23-24 24-25	0·5067091 7074 7083	0·5069513 9500 9514	0·5066102 6112 6118	0·5065351 5347 5343	0·5067014 7008 7015
	Mean & [vv]	0·5067083 145	0·5069509 122	0·5066111 131	0·5065347 32	0·5067012 29
Kew B	Oct. 14-15 15-16	0·5067024 7048	0·5069471 9490	0·5066082 6065	0·5065315 5309	0·5066973 6978
	Mean & [vv]	0·5067036 288	0·5069481 181	0·5066073 145	0·5065312 18	0·5066976 13
Kew C	Oct. 14-15 15-16	0·5067052 7064	0·5069496 9463	0·5066100 6097	0·5065329 5334	0·5066994 6990
	Mean & [vv]	0·5067058 72	0·5069480 545	0·5066099 5	0·5065331 13	0·5066992 8
Greenwich A	Oct. 20-21 21-22 22-23 23-24	0·5067104 7110 7107 7106	0·5069527 9536 9529 9522	0·5066145 6144 6151 6147	0·5065374 5383 5378 5335	0·5067038 7043 7041 7028
	Mean & [vv]	0·5067107 19	0·5069529 102	0·5066147 29	0·5065368 1450	0·5067038 134
Greenwich B	Oct. 20-21 21-22 22-23 23-24	0·5067113 7102 7097 7097	0·5069523 9525 9529 9511	0·5066135 6135 6139 6133	0·5065382 5372 5380 5368	0·5067038 7034 7036 7027
	Mean & [vv]	0·5067102 171	0·5069522 180	0·5066136 20	0·5065375 132	0·5067034 69
Kew D	Oct. 27-28 28-29 29-3) 30-31	0·5067066 7059 7068 7074	0·5069474 9462 9493 9491	0·5066098 6084 6111 6094	0·5065347 5324 5334 5338	0·5066996 6982 7001 6999
	Mean & [vv]	0·5067067 115	0·5069480 650	0·5066097 375	0·5065336 273	0·5066995 222
Kew E	Oct. 27-28 28-29 29-30 30-31	0·5067097 7060 7066 7063	0·5069477 9460 9476 9483	0·5066104 6091 6110 6085	0·5065342 5328 5323 5330	0·5067005 6985 6994 6990
	Mean & [vv]	0·5067071 886	0·5069474 290	0·5066098 398	0·5065331 195	0·5066994 218
Σ[vv]		1696	2070	1103	2113	693
p.e. of mean of day and night observations		± 6·9	± 7·7	± 5·6	± 7·8	± 4·4

$$\text{Probable error} = 0{\cdot}6745 \sqrt{\frac{\Sigma[vv]}{n - m}}$$

Where n = total number of values
m = number of groups

Two points are now worthy of attention; the first is that the several values of the time of vibration obtained at Kew differ by considerably more than the probable errors would lead one to expect.

The second point is that the probable error of a result by the mean pendulum is $\pm$ 4·4, whereas if we deduce it from the probable errors of the single pendulums we have

$$\tfrac{1}{4}\sqrt{(6{\cdot}9)^2 + (7{\cdot}7)^2 + (5{\cdot}6)^2 + (7{\cdot}8)^2}$$

$$= \pm\, 3{\cdot}6$$

The excess of the value 4·4 over 3·6 is due to the fact that all the pendulums are liable to some influence which remains constant throughout the set, but differs from day to day. It may be safely surmised that errors in the adopted clock rate are the most potent factor in this case.

To investigate the discrepancies between the several Kew results, Table XI has been formed wherein all the observations are treated as one series.

Table XI. Deduction of probable error of time of vibration of mean pendulum at Kew.

Observed time of vibration	v	vv
s		
0·5067014	19	361
·5067008	13	169
·5067015	20	400
·5066973	22	484
·5066978	17	289
·5066994	1	1
·5066990	5	25
·5066996	1	1
·5066982	13	169
·5067001	6	36
·5066999	4	16
·5067005	10	100
·5066985	10	100
·5066994	1	1
·5066990	5	25
s		
0·5066995	[vv] = 2177	

$$\text{Probable error of single value} = 0{\cdot}6745\sqrt{\frac{2177}{14}} = \pm\, 8{\cdot}4$$

$$\text{Probable error of mean} = \pm\frac{8{\cdot}4}{\sqrt{15}} = \pm\, 2{\cdot}2.$$

Here the probable error of a value of the time of vibration of the mean pendulum is $\pm$ 8·4 instead of $\pm$ 4·4, and this difference shows that a large proportion of the total error is systematic.

It is difficult to account for the discrepancies between the several results at Kew. If there were discrepancies between the different visits but none between the results of simultaneous observations, one would suspect either the flexure correction or the thermometers, imagining perhaps that the zero errors of the latter were changing; but the comparisons of the thermometers with the standards at Kew, and the severe tests to which the method of determining the flexure has been subjected at Potsdam, give us confidence in the corrections applied, and moreover errors in these corrections would not account for the difference between the two results obtained from simultaneous observations during the second visit to Kew.

The difference between these two values indicates that the clock rate is the source of error, for, whilst the clocks employed were different, all corrections were identical in these two cases. It is true that the rates of the clocks depended on the same star observations, on the same time signals, and on comparisons made by the same observer, so that a systematic error in one of the adopted values can hardly be credited. But there is another point to be considered in this connection.

Any variation in the retardation between the break of circuit in the clock and the action of the flash-lever would have the same effect as a change in the clock rate: thus if we suppose that this retardation amounted to $0^s \cdot 01$ during the observation of the first series of coincidences, and to $0^s \cdot 015$ during the second series; then, since about 35 minutes separate the two series, we should have an apparent losing rate of $0^s \cdot 005$ in 35^m, or of $0^s \cdot 2$ per day, which corresponds to a correction of 12×10^{-7} in the time of vibration. In the standard clock, Morrison 8702, electrical contact is made for a very small fraction of each second, and to obtain distinct flashes it was necessary to use great care in adjusting the balance between the spring and the electro-magnet which control the lever of the flash-box. Under these conditions it is conceivable that small changes in the attracting power of the magnet, due to an increase in the residual magnetism of the core, or to polarization of the battery, or to change in the resistance of the coils of the magnet through change of temperature, or to other such cause, may result in the armature being held a little longer or released a little sooner during the second series of observations than during the first.

The difficulty of adjusting the balance alluded to above was greatest when it was necessary, as during the second and third visits, to secure a position in which the flash-lever would respond to either of the two clocks.

The low weights of the results obtained by the Morrison Clock when used in conjunction with another confirm the idea that on these occasions some additional cause of uncertainty was at work.

Reviewing the results of Tables X and XI we may conclude that the probable error of the time of vibration of the mean pendulum, deduced from two sets of observations separated by an interval of 12 hours, will in general be

not less than $\pm$ 4·4 nor greater than $\pm$ 8·4.

To deduce the probable error of the mean of all the sets of observations at Kew and Greenwich respectively, we may have recourse to Table VIII where the various results and their weights are given.

In Table XII the figures required are repeated.

Table XII. Deduction of probable error at Kew.

Station	Determination	Time of vibration	Weight p	v	pvv
Kew	A	s 0·5067016	5	15	1125
	B	·5066980	1	21	441
	C	·5066996	8	5	200
	D	·5067000	5	1	5
	E	·5066999	2	2	8
	Weighted Mean	s 0·5067001	21		1779

Probable error of result of unit weight

$$= 0{\cdot}6745\sqrt{\frac{1779}{4}} = \pm\ 14{\cdot}2$$

Probable error of mean result

$$= \pm\ \frac{14{\cdot}2}{\sqrt{21}} = \pm\ 3{\cdot}1$$

For Greenwich we may assume that the probable error of a result of unit weight is the same as at Kew, and the sum of the weights being 16 on the same scale we may take the probable error of the mean to be

$$\pm\frac{14{\cdot}2}{\sqrt{16}} = \pm\ 3{\cdot}6.$$

Thus we have finally the following values :—

Time of vibration of mean pendulum at KEW		=	$\overset{s}{0}{\cdot}5067001 \pm 3{\cdot}1 \times 10^{-7}$
„	at GREENWICH	=	$0{\cdot}5067036 \pm 3{\cdot}6 \times 10^{-7}$
	difference	=	$0{\cdot}0000035 \pm 4{\cdot}5 \times 10^{-7}$

The final values of g at Kew and Greenwich.

The value of g at Kew may be assumed to be

$$\overset{cm}{981{\cdot}200}\ *$$

Hence, using the formula $s^2 g = s^2_0\, g_0$

or more conveniently, for small variations of s,

$$g = g_0 - 2g_0 \times \frac{s - s_0}{s_0}$$

where s_0 and g_0 are the values of the time of vibration and the acceleration of gravity at the station where both are known, and s and g those at any other station where s alone is known,

we have at Greenwich

$$g = 981{\cdot}200 - 1962{\cdot}4 \times \frac{35 \pm 4{\cdot}5}{{\cdot}5067001} \times 10^{-7}$$

$$= 981{\cdot}200 - 0{\cdot}014 \pm 0{\cdot}002$$

$$= \overset{cm}{981{\cdot}186} \pm 0{\cdot}002$$

---

* This value has been adopted by Professor Helmert in his "Bericht über die relativen Messungen der Schwerkraft mit Pendel-apparaten" which appears in the report of the Geodetic Conference of 1900—*vide* page 324.
It is based on the preliminary result of the determination of g at Potsdam, viz :— 981·274.
Cf. also Appendix No. 5 to the U.S. Coast and Geodetic Survey Report for 1901, page 355.

Theoretical values of g.

It will now be of interest to compare the theoretical values of g with the results of the observations.

In forming these values it is convenient to divide the process into five steps, each producing a correction to the fundamental value of the acceleration due to gravity at a place in latitude 0°, at sea level, far from the neighbourhood of hills or valleys, and where the geological strata have a density equal to the mean surface density of the earth. This fundamental value is taken by Professor Helmert to be 978 centimetres, and his expression for the value at sea level in latitude ϕ is

$$978\ (1 + 0{\cdot}005310 \sin^2 \phi) : \text{ this quantity is called } \gamma_0.$$

The corrections to γ_0 are:—

1. For height above sea level ... ... $-\gamma_0 \frac{2h}{R}$

2. For the mass between sea level and the station ... ... $+\gamma_0 . \frac{3}{4} . \frac{h}{R}$

3. A geological correction to allow for the actual density of the subjacent rock ... ... $-\gamma_0 . \frac{3}{2} . \frac{h'}{R} . \frac{\delta - \theta}{\Delta}$

4. A correction taking account of the actual conformation of the surrounding country, which in the above expressions has been assumed to be an extensive plain: this is called the orographical correction. It is inappreciable both at Kew and Greenwich.

In the above, h = height of station above sea level
h' = thickness of surface strata of low density
R = mean radius of the earth = 21,000,000 feet.
Δ = mean density of the earth = 5·6
δ = mean surface density = 2·8
θ = actual density of subjacent strata.

An examination of Mr. Strahan's interesting analysis of the geology of the strata underlying the observatories, reveals that under Kew there are 1140 feet of rock of average specific gravity 2·06—including 150 feet of London Clay—and 97 feet of Limestone, or in all 1237 feet of strata before the Palæozoic floor is reached.

At Greenwich the London Clay and Limestone are absent, and the estimated depth of the Palæozoic floor is 933 feet.

Therefore correction 3 becomes

For Kew ... ... $\overset{cm}{-981} . \frac{3}{2} . \frac{1140}{21,000,000} . \frac{2{\cdot}8 - 2{\cdot}06}{5{\cdot}6} = \overset{cm}{-0{\cdot}011}$

For Greenwich ... ... $-981 . \frac{3}{2} . \frac{933}{21,000,000} . \frac{2{\cdot}8 - 2{\cdot}06}{5{\cdot}6} = -0{\cdot}009$

For convenience the latitudes and heights of the stations of observation are here repeated.

	Latitude			Height
Kew	51°	28′	6″	23 feet
Greenwich	51	28	38	155 „

Table XIII. Values of the corrections and of the resulting values of g after the application of each.

Corrections	Kew		Greenwich		Difference in g
	Amount of correction	Value of g	Amount of correction	Value of g	Kew – Greenwich
	cm	cm	cm	cm	cm
Latitude ...	+ 3·178	981·178	+ 3·179	981·179	– 0·001
Height ...	– 0·002	·176	– 0·015	·164	+ 0·012
Mass ...	+ 0·001	·177	+ 0·006	·170	+ 0·007
Geological ...	– 0·011	·166	– 0·009	·161	+ 0·005
Orographical ...	0	·166	0	·161	+ 0·005

Thus the final theoretical values of g are:—

	cm
at Kew	981·166
„ Greenwich	981·161

whereas the observed values are:—

at Kew	981·200
„ Greenwich	981·186

The observed values are thus, in both cases, slightly in excess of the calculated values, and the observed difference between them is greater than the calculated difference.

The difference in the values of g at Kew and Greenwich has been determined several times: the various results obtained are here collected.

Table XIV. Difference between g at Kew and g at Greenwich.

Date	Observers	Method	Kew—Greenwich
1831 1873	Sabine, Heaviside	By determinations of length of seconds pendulums	cm + 0·069
1881	Herschel	Kater's invariable pendulums Nos. 4 and 6	cm + 0·038
1888	Constable, Hollis	Kater's invariable pendulums Nos. 4, 6 and 11	cm + 0·028
1900	Putnam	Three half-seconds pendulums	cm + 0·012
1903	Burrard, Constable, Lenox Conyngham	Four half-seconds pendulums	cm + 0·014

It is satisfactory to note that the results obtained with the modern form of apparatus agree well with each other and do not greatly differ from the value which theory demands.

This encourages the hope that the many uncertainties which have hitherto surrounded pendulum observations have been to a large extent eliminated, and that henceforward the pendulum may prove as satisfactory in practice as it has always been attractive in theory.

APPENDIX TO CHAPTER I.

On the Geology of the Strata underlying Kew and Greenwich Observatories, and on the specific gravities of the rocks of which the Strata are composed

BY

A. STRAHAN, F.R.S.

Kew Observatory stands on the right bank of the Thames, on a terrace of gravel which averages 21 feet in height above Ordnance Datum.

A well and borehole were sunk close to the same bank of the Thames at a point 160 yards below Richmond Bridge and 33 yards from high-water mark. The well is three quarters of a mile distant from the Observatory in a direction S. 22° E., and its top is 17 feet above Ordnance Datum. The Tertiary strata are nearly horizontal, as is proved by the fact that the top of the Chalk lies at nearly the same level in the well mentioned, in another at the old Richmond water-works, and in a third at the Star and Garter Hotel. The section proved, therefore, is likely to correspond closely with that which underlies the Observatory. The following account is taken from a paper by Professor Judd* and from the *Geology of London* (Memoirs of the Geological Survey) by Mr. W. Whitaker. Prominence however has been given to the lithological characters of the strata in preference to the geological grouping.

Richmond Well and Borehole.

	Thickness feet	Depth feet
Made ground ...	10	10
London Clay ...	160	170
Reading Beds: Clay ...	44	214
Reading Beds: Sand and Sandstone ...	12	226
Reading Beds: Clay ...	3½	229½
Thanet Sand ...	22½	252
Chalk with flints ...	300	552
Chalk with no flints ...	150	702
Marly Chalk ...	220	922
Sandstone (Upper Greensand) ...	16	938
Gault Clay, sandy and conglomeratic at base ...	201½	1139½
Limestone (Neocomian and Great Oolite Series) ...	97½	1237
Sandstone and indurated Marl alternating ...	117	1354
Sandstone ...	90½	1444½

* *Quarterly Journal, Geological Society*, Volume XL, page 724 (1884) and Volume XLI, page 524 (1885).

In the Limestone, at 1203 and 1210 feet depth, water was struck which rose to 46 feet from the surface, and lower down springs were met with a head of water sufficient for a rise of 126 feet above the surface.

The temperature at the bottom was 76¾° Fahr., the average increase being 1° for 54·09 feet of descent.

The strata below the depth of 1237 feet were described in the works referred to as being of doubtful age, and were temporarily called "Poikilitic", but an opinion prevailed among those who took part in the discussion that they belonged to the Old Red Sandstone. This view is supported by their character, by the fact that they dip at an angle of about 30°, whereas the Secondary rocks above them are nearly horizontal, and by their corresponding in depth to the position of the Palæozoic floor as proved in other borings in the south-east of England (see Map, Figure 1). The arguments against their being of Old Red Sandstone age are given in full by Professor Judd in the papers alluded to.

The Kew section, as estimated on the data given above, will be found drawn to scale in Figure 2.

Greenwich Observatory is situated at a height of 155 feet above Ordnance Datum on the margin of a tract of Oldhaven Beds. These strata form a gently undulating plateau, rising at a gentle angle northwards. They terminate in that direction in a bold scarp, on a projecting shoulder of which the Observatory stands. In the steep slopes which lie east and north of the building the Woolwich and Reading Beds, the Thanet Sand and the Chalk crop out from beneath the Oldhaven Beds.

A well in the garden of the Observatory is said to have reached the top of the Chalk at 75 feet depth.* The top of the well is about 10 feet below the site of the Observatory, or about 145 feet above Ordnance Datum. The top of the Chalk must therefore lie at a depth of about 85 feet below the Observatory.

The nature of the strata composing these 85 feet can be inferred from other wells in the neighbourhood.

A well at Greenwich Hospital, 770 yards to the north-west of the Observatory yields the following details:—*

		Thickness		Depth from surface	
		ft.	in.	ft.	in.
Made ground		11	0	11	0
Gravel, in part Blackheath (or Oldhaven) Beds		33	0	44	0
Woolwich and Reading Beds 25½ feet	Black sand	4	10	48	10
	Blue clay		8	49	6
	Shelly rock	4	0	53	6
	Red clay	6	0	59	6
	White sand (water)	4	0	63	6
	Green sand and pebbles	4	0	67	6
Thanet sand (water)		55	10	123	4
Bed of flints		1	0	124	4

The strata vary in detail, but the occurrence of pebble-beds in the Oldhaven and Woolwich Beds, and of bands of clay in the latter is a fairly constant feature. In default of more precise information the lower 85 feet of this section may be taken to represent the strata which rest upon the Chalk under the Observatory.

The thickness of the Chalk must be estimated from more distant sources.

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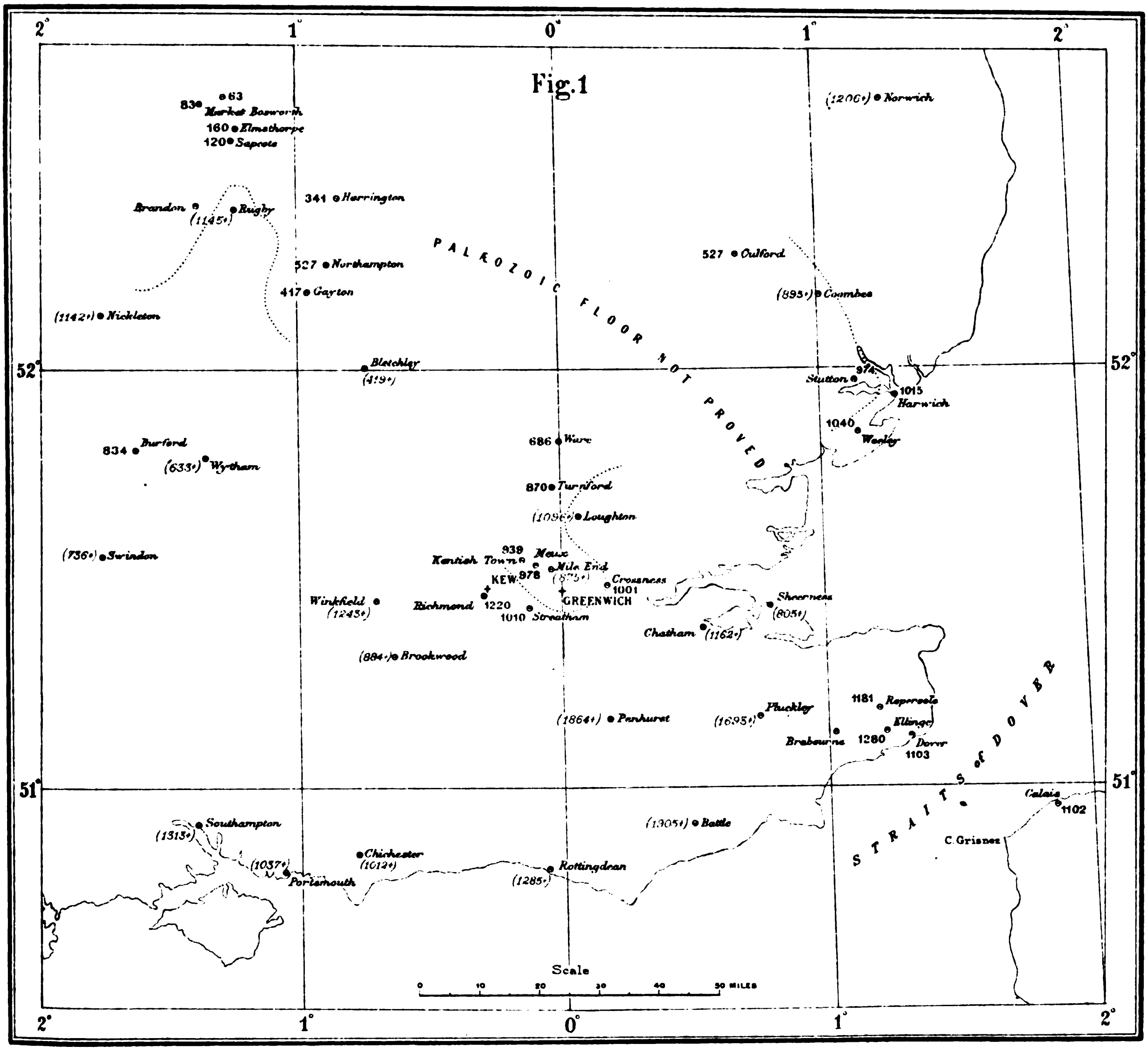
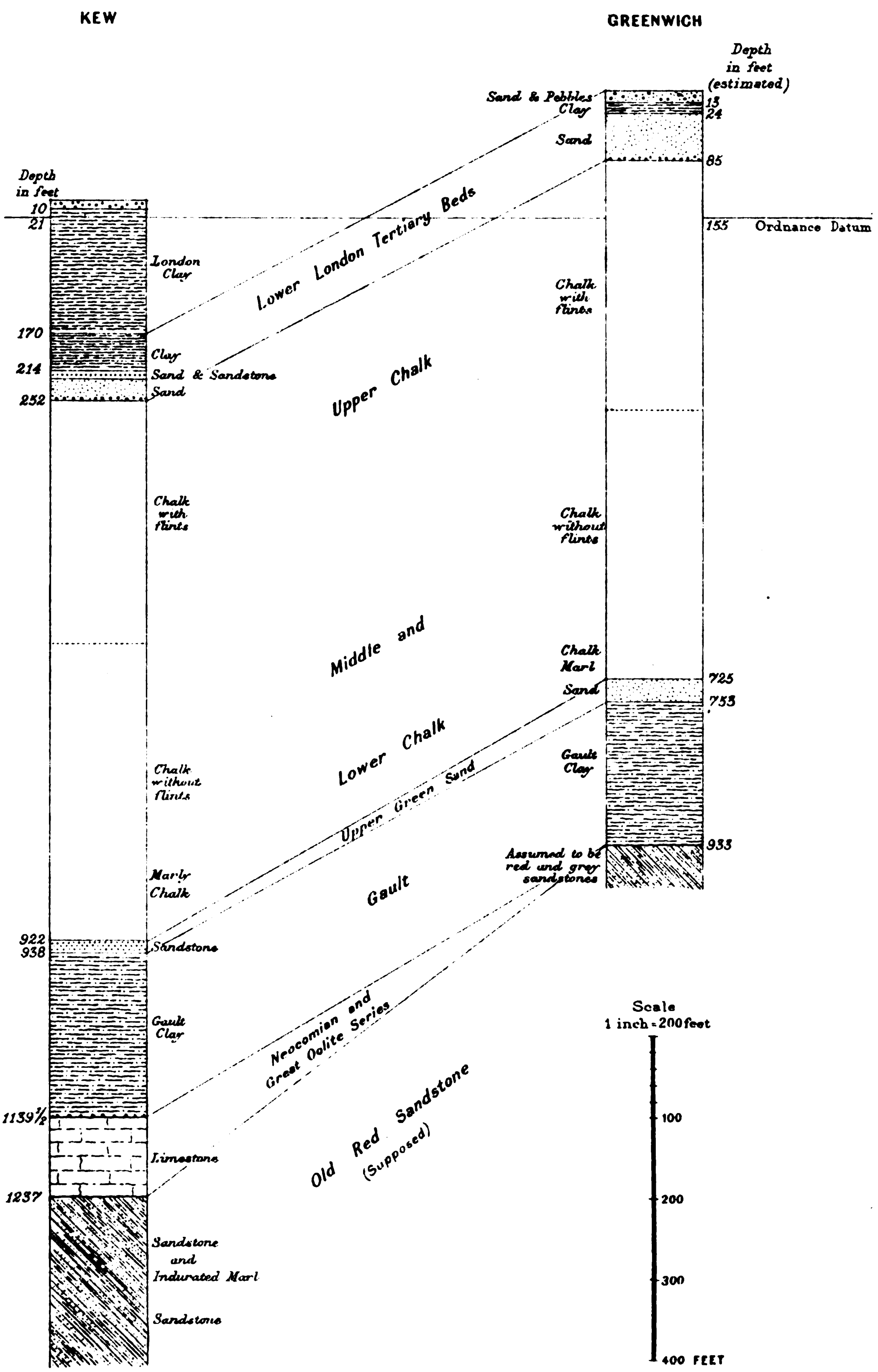
* *Geology of London*, Volume II, page 73.



The sites of boring are shewn thus ●
The depth of the palæozoic floor below O.D. where proved is given in feet thus 1056
The depth of borings which did not reach palæozoic rocks is given in feet thus (1905+)
A contour-line on the palæozoic floor at 1000 feet below O.D. is shewn thus ....

Fig. 2


KEW
GREENWICH
Depth in feet
Depth in feet (estimated)
10
21
London Clay
170
Clay
214
Sand & Sandstone
252
Sand
Chalk with flints
Chalk without flints
Marly Chalk
922
938
Sandstone
Gault Clay
1139½
Limestone
1237
Sandstone and Indurated Marl
Sandstone
Sand & Pebbles
Clay
Sand
13
24
85
155
Ordnance Datum
Chalk with flints
Chalk without flints
Chalk Marl
Sand
725
753
Gault Clay
933
Assumed to be red and grey sandstones
Lower London Tertiary Beds
Upper Chalk
Middle and
Lower Chalk
Upper Green Sand
Gault
Neocomian and Great Oolite Series
Old Red Sandstone (Supposed)
Scale
1 inch = 200 feet
100
200
300
400 FEET

At Mile End a well was sunk for the Albion Brewery at 172 Whitechapel Road.* It reached the top of the Chalk at a depth of 201 feet, and its bottom at 855 feet, proving its thickness to be 654 feet. The Chalk contained flints and layers of flint in the upper 259 feet. The remainder was hard and flintless, becoming marly towards the bottom. This well is situated 3⅞ miles from the Observatory in a direction N. 39° W.

A well at Meux Brewery† at the junction of Tottenham Court Road and New Oxford Street is situated 6½ miles from the Observatory in a direction W. 26° N. Here the top of the Chalk was reached at a depth of 157½ feet and the bottom at 812 feet, giving a total thickness of 654½ feet. Flints occurred in the upper 347 feet, and for 32 feet upwards from its base the Chalk was described as a chalk marl or a light-blue clay.

A well near Streatham Common Station‡ is situated 7½ miles from the Observatory in a direction W. 36° S. The top of the Chalk was reached at a depth of 241½ feet and its bottom at 864½ feet, indicating a thickness of 623 feet. The upper 220 feet are described as containing flints and being very hard, and the lower 20 or 30 feet as being marly and clayey.

A well at Crossness§, situated 7¾ miles from the Observatory in a direction E. 3° N., proved the top of the Chalk at a depth of 143½ feet and the bottom at 802 feet, giving a thickness of 658½ feet. Flints were more or less plentiful in the upper 447 feet and the lower 32 feet were grey marl.

On comparing these data we find that the thickness of the Chalk under the Observatory, as judged by the Crossness and Mile End wells, is likely to be between 654 and 658 feet, but that the Streatham Common Well indicates a southerly attenuation. As the Observatory lies south of a line drawn from Crossness to Mile End, this attenuation must be taken into account, and the thickness under the Observatory may be estimated at 640 feet. The Upper Greensand lies next below the Chalk. In one of the borings at Crossness its thickness is given as 65 feet, but there is no doubt that this includes some chalk marl, as suggested by Prestwich.‖ At Mile End it was penetrated to a depth of 20 feet, and at Meux Brewery and at Streatham it was proved to be 28 and 28½ feet thick respectively. It may be assumed to be 28 feet thick under the Observatory.

The Gault was 175 feet thick at Crossness, 160 feet at Meux Brewery and 188½ feet at Streatham Common. It is likely to be 180 feet thick under the Observatory.

Below the Gault there may be some Jurassic strata. At Meux Brewery 64 feet of limestone belonging to the Great Oolite Series were penetrated, and at Streatham Common 38½ feet of limestone and clay believed to belong to the Forest Marble. It has already been noted that there were 97½ feet of limestone below the Gault at Richmond, part of which however were thought to be of Neocomian age. On the other hand at Crossness the Gault has been proved to lie directly upon Palæozoic rocks‖. These facts indicate a westward thickening of the Jurassic strata. They come in again eastwards of Crossness also as proved at Chatham but whether they exist under Greenwich is doubtful. On the whole it will probably be safer to assume their absence.

The depth at which the Palæozoic rocks are likely to occur beneath Greenwich Observatory remains to be considered. At Crossness rocks described as rock-shale and very hard grey quartzose sandstones were reached at 1002 feet below Ordnance Datum. They were assigned by Prestwich to the Old Red Sandstone or Devonian, but were thought by Mr. Whitaker to be more probably Triassic¶. At Meux Brewery red and green shales with thin quartzites, all assigned to the Upper Devonian, were reached at 979 feet below Ordnance Datum. At Streatham Common red, grey and greenish sandstones were reached at 1010 feet below that datum. At Richmond alternations of sandstone and indurated marl were reached at 1220 feet below that datum. The red and greenish sandstones reached at Streatham were left by Mr. Whitaker as "of doubtful age", but they correspond in character to parts of the Old Red Sandstone of South Wales. This

* J. Barrow. *Proc. S. Wales Inst. Eng.* Volume XI, page 326 and *Geology of London*, Volume II page 135 (188) This and the other deep wells referred to are shewn in Figure I.

† Prestwich and Moore, *Quarterly Journal Geological Society*, Volume XXIV, page 902 and *Geology of London* Volume II, page 165, (1889).

‡ *Geology of London*, Volume II, page 224. (1889).

§ *Geology of London*, Volume II, page 66. This is not the deep boring referred to later on.

‖ *Quarterly Journal, Geological Society*, Volume XXXIV, page 913 (1878).

¶ *Geology of London*, Volume II, page 68.

similarity taken in connection with the fact that they dipped at about 30° and occurred at about the depth at which the Palæozoic floor might be expected, seems to justify their being assigned to the Old Red Sandstone. For the same reasons the red rocks proved at Richmond are more probably of Devonian than of Triassic age.

If the Palæozoic floor were a plane its depth under Greenwich could be calculated precisely from these data, but it is known to undulate, though it rises on the whole with a remarkably even and gentle gradient towards the north or north-east under London. Judged by the Meux and Streatham sections it would be about 990 feet below Ordnance Datum, but on adding up the thicknesses assigned above to the Tertiary and Secondary strata we get a depth of only 930 feet. The latter is probably the more reliable estimate, and the complete sequence of the strata underlying Greenwich Observatory will therefore be as follows (see also Figure 2) :—

		Thickness feet	Depth feet
Lower London Tertiary Beds 85 feet	Sand and pebbles	13	13
	Blue and red clay	11	24
	Sand, with a layer of flints at the bottom	61	85
Chalk 640 feet	Chalk with flints	310	395
	Chalk without flints	300	695
	Chalk marl	30	725
Upper Greensand	Sand	28	753
Gault	Clay	180	933

Palæozoic Rocks, assumed to be red, grey and greenish sandstone as at Streatham Common.

The Observatory being 155 feet above Ordnance Datum the Palæozoic floor will be only 778 feet below that datum. The highest points in that floor yet proved in the London district are Kentish Town, Turnford and Ware, where it lay 939, 870½ and 686½ feet respectively below Ordnance Datum. Its calculated height under Greenwich was therefore somewhat unexpected.

Its height is accounted for by an anticline and fault which trend in a direction E. 30° N. on the north-west side of the Observatory. The existence of the anticline is proved by the depths at which the top of the Chalk has been reached in various borings. Near Blackheath the Chalk was touched at about Ordnance Datum, but in the Observatory well at 70 feet above that datum, the rise therefore being 70 feet in about half a mile, or about 1 in 38, towards the north-west. Again at the Hospital the top of the Chalk lies 98 feet below Ordnance Datum and at the Atlas Works in West Ferry Road,* on the opposite side of the river, at 84 feet below the datum, proving that the rise north-westwards continues thus far, as shewn in Figure 3. But a little further north its depth increases to 100 and 200 feet below the datum.

The fault is believed to run about 300 yards north-west of the Observatory. It is referred to by Mr. Whitaker as the most important fault (or system of faulting) in the London Basin. It was seen in two railway-cuttings south of Deptford†, and is fixed approximately in position by a well in East Street, Greenwich, where the top of the Chalk lies 134 feet below Ordnance Datum, and 204 feet below its level under the Observatory. Beyond this it is believed by Mr. Whitaker to curve southwards by Woolwich and to merge into the slight roll that affects the junction of the Tertiary Beds and the Chalk on the north side of the Thames near Purfleet and Stifford. The throw of the fault at Greenwich must be 204 feet plus an allowance for the dip, or about 230 feet in all.

There can be no doubt therefore that the Palæozoic floor has been raised locally under Greenwich by post-Tertiary earth-movements, though that there was pre-Cretaceous elevation also of part of the district is proved by the fact that the Gault rests directly upon that floor at Crossness. The following table gives the depths at which the floor has been reached in various parts of the south-east of England.

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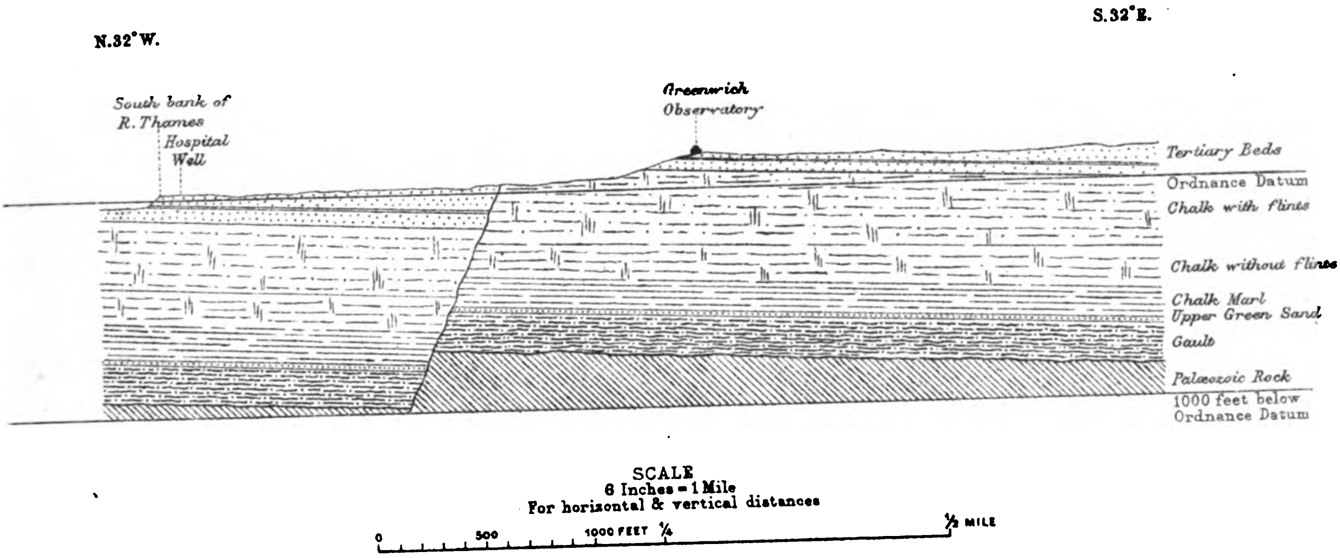
* *Some Middlesex Well-sections. Trans: Brit: Assoc: Water-works Eng.*, Volume II. 1897.

† *Geology of London*, Volume I. page 485. 1889.

Fig.3



N.32°W.
S.32°E.
South bank of
R. Thames
Hospital
Well
Greenwich
Observatory
Tertiary Beds
Ordnance Datum
Chalk with flints
Chalk without flints
Chalk Marl
Upper Green Sand
Gault
Palæozoic Rock
1000 feet below
Ordnance Datum
SCALE
6 Inches = 1 Mile
For horizontal & vertical distances
0
500
1000 FEET
¼
½ MILE

Depths to the Palæozoic floor in the east and south of England. *(See Figure 1.)*

	Depth from surface feet	Depth below Ordnance Datum. feet
Harwich	1025½	1015
Stutton	994	974
Weeley	1094½	1040*
Ware	796½	686½
Turnford	980½	870½
Loughton	(not reached at 1096)	...
Kentish Town	1113	939
Meux Brewery	1064	978½
Streatham	1120	1010
Richmond	1237	1220
Crossness	1008	1001½
Brabourne	1905	...
Ropersole	1581	1181
Ellinge	1686	1280 (about)
Dover No. 2 Shaft	1157	1103

To the west of London a boring at Winkfield near Windsor failed to reach Palæozoic rocks at 1243 feet (1025 feet below Ordnance Datum).

To the south-west a boring at Brookwood ended in Chalk at 884 feet; others at Southampton, Portsmouth and Goodwood left off in Chalk at 1313, 1037 and 1012 feet respectively.

To the south and south-east a boring at Penshurst was in Kimeridge Clay at 1864 feet and one at Warren Farm, the Industrial School east of Brighton, was in Lower Greensand at 1285 feet. The Sub-Wealden boring at Battle left off in Oxford Clay at 1905 feet.

To the east-south-east the Pluckley boring was abandoned in Kimeridge Clay at 1698 feet, but the Brabourne boring reached Palæozoic rocks at 1905 feet. Further east the Ropersole and Ellinge borings have reached Coal Measures at depths of 1581 and 1686 feet (1181 and 1280 feet below Ordnance Datum) respectively, while the Dover Shaft, No. 2, has entered them at a depth of 1157 feet or 1103 below Ordnance Datum.

At Calais the Palæozoic floor was reached at 1102 feet.

To the east of London a boring at Chatham ended in Oxford Clay at 965 feet and another at Sheerness ended in Chalk at 805 feet.

From these data it is possible to contour parts of the Palæozoic floor. For example a contour-line drawn at 1000 feet below Ordnance Datum runs between Ware and Winkfield, and must trend generally north-westwards between Northampton and Rugby. In the opposite direction it passes between Kentish Town and Richmond, runs close to Streatham and through Crossness, but keeps clear of Chatham where one boring ended in Lower Greensand at 1035 feet, while another ended in Oxford Clay at 947 feet below Ordnance Datum, probably not far above the Palæozoic rocks. The Dover Shaft, No. 2, entered the Coal Measures at 1103 feet below Ordnance Datum, nor have the older rocks been found to the south-east of Crossness within 1000 feet of Ordnance Datum. The contour-line must therefore double back to the north-west passing between Loughton and the other neighbouring borings. Thence its position is hypothetical as far as Harwich, where it is determined by the Harwich, Weeley and Stutton borings. Further north it probably passes near Coombs, where a boring ended in Gault at 895 feet, and certainly keeps to the east of Culford where a boring reached Palæozoic rocks at 637 feet (527 feet below Ordnance Datum).

Nothing is known of the Palæozoic rocks of the broad tract between Culford, Harwich Crossness and Ware. The Loughton boring, which failed to reach them at 1096 feet, shews that it would not be safe to assume that they lie within 1000 feet of Ordnance Datum over the whole of the tract, but for the purposes of the present enquiry this is immaterial.

* I have been unable to ascertain the height of the site of the boring above Ordnance Datum. This figure is calculated on the assumption that the height is between 50 and 60 feet.

As regards the structure of the Palæozoic floor it is known only that Silurian rocks were reached at Ware and Devonian at Meux Brewery, in Tottenham Court Road. Old Red Sandstone was recognised at Crossness, and occurred probably at Kentish Town, Richmond and Streatham also. The relative positions of these rocks suggest a southerly dip, and some experiments at Turnford and Ware indicated a dip of 25° in a direction S. 25° W. and a dip of 41° in a direction S. 1° W., at the two places respectively*. At Richmond and elsewhere the dip was about 30°; but at Brabourne much higher, a fact which suggests that the nearly horizontal Coal Measures proved at Dover and Ropersole are terminated westwards by a fault, not improbably the continuation of one of the great lines of disturbance proved in the Pas de Calais Coal Field.

It will be seen therefore that there is a gentle eminence in the Palæozoic floor, running in a north-west, or west-north-west direction under London, and extending, but with diminished height, towards Dover in the opposite direction. Towards the south-west the slope as reckoned between Ware and Richmond falls at the rate of about 1 in 257, but the floor undulates and between Kentish Town and Richmond the gradient amounts to about 1 in 141. Kew Observatory stands over this steeper part of the slope. Under Greenwich the floor appears to be gently arched up and faulted as described, the Observatory being situated on the southern side of the crest of the arch.

The principal differences therefore between the stratigraphical columns beneath the two Observatories may be summed up as follows:—

Under Kew Observatory there are 150 feet of London Clay near the surface and 97½ feet of Limestone at a depth, both of which are absent at Greenwich.

Under Kew the Palæozoic floor lies at a depth of 1237 feet below the surface as compared with 933 feet at Greenwich.

Lastly Greenwich Observatory stands on the southern limb of a gentle post-Tertiary anticline.

Specific Gravities.

The following specimens were collected for the purpose of ascertaining the specific gravities of the various rocks underlying Kew and Greenwich:—

1. London Clay from a depth of 60 to 70 feet under St. George's Circus, Blackfriars Road.
2. Do. do. 60 feet under Hyde Park Corner.
3. Do. do. 36 feet under Jermyn Street.
4. Woolwich and Reading Beds (Clay); Crondall Pottery, Surrey.
5. Thanet Sand; Charlton.
6. Upper Chalk; Charlton.
7. Flint; Charlton.
8. Chalk Marl from a depth of 450 feet; Chatham Waterworks.
9. Upper Greensand from a depth of 823 feet; Richmond Boring.
10. Upper Greensand; Merstham.
11. Gault from a depth of 990 feet; Meux Brewery, Tottenham Court Road.
12. Great Oolite (limestone) from a depth of 1001 to 1065 feet; Richmond Boring.
13. Old Red Sandstone from a depth of 1411 feet; Richmond Boring.
14. Do. (marl) 1180 feet; Streatham Boring.
15. Do. do. 1204 feet; do

The determinations were made in the laboratory at Jermyn Street by Dr. W. Pollard, from whose report I have drawn up the following account:—

The specimens were roughly crushed so as to pass through a sieve of 8 holes to the inch. Moisture given off at 105° C. was determined. The specific gravity of the samples before drying was determined in pyknometers, and that of the dried rock calculated.

To ascertain the amount of water the dried specimens were capable of absorbing, glass tubes open at one end, and with a piece of linen tied over the other, were used. The weight of the tubes after moistening the linen and allowing to drain thoroughly was determined. The tubes

* J. Francis: *Report, Brit: Assoc*: 1895, page 441.

were then filled with the respective specimens, weighed, and placed in distilled water for 24 hours, so as to allow the water to soak upwards into them. When they were thoroughly soaked any excess of water was allowed to drain off in an atmosphere saturated with moisture. They were then weighed at weekly intervals. After seven weeks some had become constant, but others continued to lose moisture after 10 weeks, when the experiment was discontinued. The results obtained are shewn in the following table:—

No. of specimens	Specific gravities as calculated for the dried rock	1 part of water by weight retained in parts of each specimen		Days after commencement of experiment
1	2·76	1·77*	and 1·66*	49
2	2·76	1·75*	1·69	49
3	2·77	2·05	2·01*	49
4	2·88	2·32	2·40	77
5	2·66	4·37	4·42	76
6	2·72	2·99	3·08	76
7	2·60			
8	2·77	2·84	3·02	76
9	2·73	4·10	4·34*	75
10	2·54	2·52	2·83*	75
11	2·76	2·19	2·34	73
12	2·73	10·95*	10·82*	63 and 73
13	2·65	144	166	
14	2·74	24·76		
15	2·76	128		

Dr. Pollard further notes, as sources of error, that the tubes were not packed under the conditions of pressure &c., which obtain at a depth, and that changes of temperature in the laboratory probably account for some irregularities observed in the draining off of the water.

No. 7 (Flint) was considered to be non-absorbent. The specific gravities of Nos. 13, 14 and 15 (Old Red Sandstone and Marl) were determined by suspending them in water allowing them to drain for a few hours in a moist atmosphere, then weighing, drying at 105° C. and weighing again.

It being evident that no confidence could be placed in the determination of the water-capacity of some of the specimens, it was decided to make further experiments on specimens in as nearly as possible the condition as to moisture in which they occurred in nature. For this purpose the following rocks were freshly dug, enclosed at once in tin boxes and brought to the laboratory:—

1. London Clay from a depth of 60 feet; Dover Street, Piccadilly.
2. Upper Chalk; Strood, Kent.
3. Middle Chalk; Blue Bell Hill Upper Pit, Burham, Kent.
4. Lower Chalk; Merstham, Surrey.
5. Chalk Marl; Blue Bell Hill Lower Pit, Burham, Kent.
6. Gault; Burham Brick Pit, Kent.

The specific gravity of each specimen in the condition in which it reached the laboratory was determined in various oils. The result was satisfactory for the Clays, but not for the Chalks from which the air could not be removed. In every case a determination was made also by pyknometer.

* This weighing varied by 0·1 gram or less from the previous weighing and is regarded as practically constant.

No. of specimen	Sp. Gr. in oil	Sp. Gr. in water	Percentage of water by weight	Sp. Gr. of dried specimen in pyknometer	Sp. Gr. calculated from that of the moist specimen
1	2·054*	2·050	19·66	2·746	2·760
2	2·026	2·072	18·33	2·673	2·729
3	2·395†	2·405	7·29	2·694	2·701
4	2·048	2·062	18·27	2·702	2·703
5	2·096‡	2·108	16·54	2·700	2·701
6	1·995	1·995	21·12	2·718	2·719

It will be seen that the specific gravities of all the specimens except the Clays are lower as determined in oil than in water, which points to the air not having been entirely eliminated.

The calculated specific gravity is also in every case slightly higher than that directly determined on the dried sample in the pyknometer. This is probably due to the dried powder having absorbed moisture on the balance.

With respect to specimen 3 the moisture percentage is probably much too low and the other results unreliable. This may be due to the specimen having lost water in the quarry, though it was got in as nearly a natural condition as possible. Two lumps were therefore suspended and boiled in water for two or three hours, and when cold weighed in water. They were then allowed to drain for 15 minutes, weighed, drained for another 15 minutes, reweighed and finally dried at 105° C. From these data the specific gravity was found to be

Wet Samples 2·016 and 2·072
Dry Samples 2·511 and 2·558

Water percentage (by weight) in wet sample 16·14 and 15·04.

The specific gravities thus determined are 0·190 and 0·143 respectively lower than the calculated specific gravity. The difference is probably due to incomplete drying and to some air being still contained. The percentage of water, however, is probably nearer that which exists in the Chalk under the Observatories than the percentage given in the table.

In summing up these results, we must bear in mind that there are several discrepancies which point to the advisability of further experiments, and that an absolutely true result could be obtained only by experimenting on the rocks in the conditions of moisture and pressure in which they occur in nature. The results, so far as the experiments have gone, are embodied in the following table:—

	Specific gravity in natural condition	Percentage of water by weight
London Clay	2·050	19·66
Upper Chalk	2·072	18·33
§Chalk-flint	2·600	
Lower Chalk	2·062	18·27
Chalk Marl	2·108	16·54
Gault	1·995	21·12
‖Great Oolite limestone	2·383	8·42
‖Old Red Sandstone	2·622	0·65
‖ Do. (marl)	2·567	3·88
‖ Do.	2·723	0·77

* A specimen dried at 105° C. gave a specific gravity of 2·739 in the oil.
† After being in vacuo all night: all the figures relating to No. 3 in the table are probably unreliable.
‡ After being in vacuo for 48 hours.
§ Flint-layers may be estimated to constitute about 1¼ per cent of the Upper Chalk.
‖ The figures calculated from the table on page 37.

CHAPTER II.

The Observations in 1904.

[January to June].

On the arrival of the pendulum apparatus in India in January 1904 a set of observations was made in Dehra Dún in the same room as had been used by Captain Basevi in 1870 and 1871. The primary object of these observations was to determine the difference between the value of *g* at Dehra Dún and its value at Kew. A secondary object was to establish a connection between the new series of observations and those made between 1865 and 1870 by Captains Basevi and Heaviside. In order to strengthen this connection it was decided that during the first tour four more of Basevi's stations should be visited, namely Calcutta, Madras, Bombay and Mussooree, and that the circuit should be completed by a second visit to Dehra Dún.

The building in which Basevi observed in Mussooree has changed hands, and though permission to observe there on this occasion was obtained, it seemed unlikely that it would be again available, and a second station in Mussooree was therefore selected in case of its proving desirable at any future time to make another set of observations which should be comparable with those of the present series.

Dehra Dun.

Latitude ...	...	30°	19′	29″
Longitude ...	...	78	3	15
Height above mean sea level	...	2239 feet		

The apparatus was set up in the room known as the Transit room. It was in this room that Basevi observed and the new pendulum station is almost identical with the old one.

A small pedestal of brick in cement was built to receive the pendulum stand. Its dimensions were 2 feet 3 inches square at bottom, 1 foot 6 inches square at top, and 1 foot 8 inches high.

Similar pedestals were built at all the stations visited during this season. The granite slab was cemented to this pedestal, and the pendulum stand was screwed tightly to the slab.

The clock S.R. 238, was set up on an iron tripod stand which had been made in Dehra Dún. The tripod has three levelling screws which can be firmly clamped.

The time observations were made with Transit Instrument No. 2. by Messrs. Troughton and Simms, which belongs to the Longitude equipment purchased in 1894. The transits were recorded on one of the chronographs of the same equipment. In January and February 1904, break-circuit chronometer Bond No. 480 was used for the star transits and the rate of S. R. 238 was deduced by means of comparisons made on the chronograph.

All the star observations in January and February were made by Lieut. H. M. Cowie, R. E. The programme contained from 8 to 12 zenithal stars, and 2 or 3 polar stars for the determination of the deviation in azimuth. The same stars were observed each night.

The thermometers were the same as those used at Kew and Greenwich.

The temperature conditions were not very good. The room is large and lofty but the roof is of iron and in the day time there was an appreciable rise of temperature. A lag correction has consequently been applied both here and at all the stations of this season, employing the same formula as had been used at Kew and Greenwich.

The flexure correction was determined seven times. On the first three occasions I forgot to place the screen between the driving and the driven pendulums; when I discovered its omission I made further observations with and without the screen so as to ascertain what difference the absence of the screen would make in the correction. It was found that with the screen in position the correction was greater by $4\overset{s}{\cdot}3 \times 10^{-7}$ than when the driven pendulum was unprotected from the air set in motion by the driving pendulum. This result was to be expected, for the driven pendulum follows a quarter of an oscillation behind the other, so that the air set in motion has a retarding effect on its movement.

The results of the flexure observations are shewn in the following table:—

Date 1904		Flexure Correction	
		Without Screen	With Screen
		s	s
January	20	$28{\cdot}3 \times 10^{-7}$	$32{\cdot}6 \times 10^{-7}$
"	21	29·7	34·0
"	29	30·4	34·7
February	8	...	35·3
"	8	...	34·4
"	9	...	35·2
"	9	...	35·8
Mean		...	$\overset{s}{34{\cdot}57} \times 10^{-7}$
Adopted Correction		...	$-\overset{s}{35} \times 10^{-7}$

Calcutta.

The room in which Captain Basevi observed was no longer available, but the Rector of St. Xavier's College kindly placed the lower storey of the observatory in the college grounds at my disposal. The observatory is less than 100 yards from Basevi's station.

The observations began at night and passed without incident, but next day when I began to observe I found that the arc of vibration kept changing and that the time of oscillation was quite irregular.

The cause of the irregularity was unquestionably earth-tremors set up by the traffic. The whole city of Calcutta may almost be said to be floating and the movement of vehicles sets up waves in the flexible crust.

The following is the record of one of several series of observations of the amplitude of the vibration of a pendulum, caused by these waves, the pendulum having been completely brought to rest at the beginning of the observation.

Time		Arc of vibration	Time		Arc of vibration
m	s	′	m	s	′
20	20	... 0	27	40	... 0
	40	... 4	30	15	... 5
21	25	... 0	31	50	... 9
	50	... 2	32	45	... 12
23	0	... 0	34	30	... 14
	30	... 2	38	0	... 17
24	30	... 3	39	40	... 11
26	30	... 4	41	35	... 7

The irregularity in the time of vibration was well shewn by the fact that the estimated time of the 61st coincidence, which in general is not in error by more than 1^s or 1^s·5, was here apt to be wrong by fully 10 seconds.

Different times of the day, and planes of oscillation in different azimuths were tried, but without producing any improvement. It was clear that it was impossible to obtain a trustworthy result in this part of Calcutta, and the observations were abandoned.

When Basevi observed here 24 years ago it is probable that the vibrations of the ground were much less marked than they are now, for there has been a great increase in the volume of the traffic in the interval; furthermore it is very likely that the long pendulums used by him were less sensitive to these tremors on account of their greater period.

I am surprised however that I have come across no mention of this difficulty in connection with the Austrian pendulum observations. It appears* that two separate sets of observations were made, the one in 1893 and the other in 1897, and both in the very same place as that which I occupied, and with precisely similar pendulums. Yet though allusion is made to ground vibrations in other places (*e.g.* Port Said & Yokohama) nothing is said of any trouble in Calcutta.

Madras.

Latitude ...	...	13°	4′	8″
Longitude ...	...	80	14	54
Height above mean sea level ...	...		20 feet	

The room in the observatory which had been occupied by Basevi was available, and was kindly placed at my disposal by Professor R. Ll. Jones, the Director. The arrangements were the same as in Dehra Dún, except that the time determinations were undertaken by Mr. Solomon, the First Assistant in the observatory, with the large transit instrument. The sidereal clock belonging to the observatory is not provided with electrical contacts and I therefore made the comparison between it and S. R. 238 by means of a mean time chronometer which was lent me for the purpose.

The temperature conditions were satisfactory. The flexure was determined six times with the following results:—

Date		Flexure Correction
March 3	...	$38{\cdot}6 \times 10^{-7}$ s
" "	...	41·7
" 6	...	37·8
" "	...	38·4
" 8	...	38·4
" "	...	37·0
Mean	...	$38{\cdot}7 \times 10^{-7}$ s
Adopted Correction	...	-39×10^{-7} s

Colaba.

Latitude ...	...	18°	53′	45″
Longitude ...	...	72	48	47
Height above mean sea level ...	...		34 feet	

The out-building of the observatory which was lent to Captain Heaviside in 1873 was kindly placed at my disposal by Mr. Moos, the Superintendent. The position of this building is not very well suited to pendulum observations as it lies very near the public road and the floor is consequently somewhat liable to surface vibrations.

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* *Comptes-rendus de la Treizième Conférence Générale de l' Association Géodésique Internationale*, 1900. p. 184.
It is possible that there is some mistake about the place in which the observations of 1897 were made, for the authorities at St. Xavier's College, though they knew all about the observations of 1893, had no recollection of any in 1897.

The rate of the clock was determined by transits which I observed myself with Transit Instrument No. 2. by Troughton and Simms. The programme included 12 zenithal and 4 polar stars. The clock's rate was rather unsteady, this may have been due to vibrations of the floor.

The temperature conditions were fairly satisfactory.

The flexure correction was determined six times with the following results:—

Date			Flexure Correction
			s
March	16	...	$39{\cdot}5 \times 10^{-7}$
"	"	...	39·4
"	20	...	36·1
"	"	...	38·9
"	23	...	38·2
"	"	...	38·5
			s
Mean		...	$38{\cdot}4 \times 10^{-7}$
			s
Adopted Correction		...	-38×10^{-7}

Mussooree (*Dunseverick*).

Latitude ... ... 30° 27′ 28″
Longitude 78 3 33
Height above mean sea level ... ... 7129 feet

The apparatus was erected in a room in the lower storey of the house called Dunseverick. This house is situated on the eastern end of a ridge which runs nearly due east and west; the ground falls very steeply on three sides, but on the fourth it continues at about the same level, though with irregular ups and downs, for about 7 miles and then descends gradually to the Jumna.

There is a bench-mark of the G. T. Survey in the verandah just outside the pendulum room, so that the height above sea level is known with an unusual degree of accuracy for a station in the hills. The temperature conditions were good.

I made the time determinations myself, using Transit Instrument No. 2 by T. & S.

The flexure correction was determined six times with the following results:—

Date			Flexure Correction
			s
April	21	...	$41{\cdot}5 \times 10^{-7}$
"	"	...	41·0
"	25	...	40·5
"	"	...	39·1
"	27	...	40·9
"	"	...	41·7
			s
Mean		...	$40{\cdot}8 \times 10^{-7}$
			s
Adopted Correction		...	-41×10^{-7}

Mussooree (*Camel's Back*).

Latitude ... ... 30° 27′ 35″
Longitude 78 4 32
Height above mean sea level ... ... 6924 feet

This was Basevi's station. The house which he built expressly for the pendulums, and which was close to the house formerly used as the G. T. Office, had when I reached Mussooree been almost entirely pulled down, with a view to the erection of a larger one. The owner however gave me permission to use a part of the new house as soon as the roof was on, and before the inside fittings were commenced. The roof was of iron, so to improve the temperature conditions I had a temporary thatch laid on the top of it.

The exact site of Basevi's pillar was not discoverable, but the new station is certainly not as much as 10 feet from the old one.

The height above M. S. L. was obtained by levelling from a bench-mark of the G. T. Survey which was only a few yards away.

I made the time determinations myself.

The flexure correction was determined four times with the following results:—

Date		Flexure Correction
May 12	...	s 38·7 × 10⁻⁷
" "	...	37·5
" 20	...	36·0
" "	...	35·3
Mean	...	s 36·9 × 10⁻⁷
Adopted Correction	...	s − 37 × 10⁻⁷

Dehra Dun.

Latitude ... ... 30° 19′ 29″
Longitude 78 3 15
Height above mean sea level ... ... 2239 feet

The closing observations in Dehra Dún were made in the same room as were those at the beginning of the tour. Two series of observations were made; during the first the break-circuit chronometer Bond 480 was used both for stars and pendulums, and the transits were observed partly by me and partly by Sub-assistant Superintendent Hanuman Prasad.

During the second series the clock S. R. 238 was used and all the star observations were made by Babu Hanuman Prasad.

The temperature conditions were not very satisfactory.

The flexure correction was determined five times as follows:—

Date		Flexure Correction
May 26	...	s 29·7 × 10⁻⁷
" 27	...	29·5
" 30	...	30·3
" "	...	27·8
June 5	...	28·4
Mean	...	s 29·1 × 10⁻⁷
Adopted Correction	...	s − 29 × 10⁻⁷

Table I. Details of the Observations.

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
	Dehra Dun—(*Basevi's Station*).														
	25-26 January, 1904.														
	h m	s	s	′	°	°		s							s
137	5 21	34·413	−1·88	16	13·31	−0·01	0·881	0·5073717	+110	−7	−652	0	−523	−35	0·5072610
139	6 14	34·863	1·88	14	13·34	0·01	0·881	0·5072753	110	5	654	0	534	35	0·5071635
138	7 8	33·347	1·88	15	13·32	0·01	0·881	0·5076111	110	6	653	0	504	35	0·5075023
140	7 59	35·224	1·88	14	13·29	0·01	0·881	0·5071997	110	5	651	0	534	35	0·5070882
													Mean	...	0·5072538
137	17 24	34·463	−1·88	15	11·82	+0·57	0·883	0·5073610	+110	−6	−579	+14	−525	−35	0·5072589
139	18 15	34·900	1·88	15	12·25	0·57	0·882	0·5072675	110	6	600	14	534	35	0·5071624
138	19 9	33·374	1·88	14	12·82	0·57	0·878	0·5076048	110	5	628	14	502	35	0·5075002
140	20 3	35·243	1·88	16	13·30	0·57	0·875	0·5071958	110	7	652	14	530	35	0·5070858
													Mean	...	0·5072518
									Time of Vibration of Mean Pendulum					...	**0·5072528**
	26-27 January, 1904.														
140	5 35	35·215	−1·73	16	13·55	−0·01	0·877	0·5072016	+102	−7	−664	0	−531	−35	0·5070881
138	6 29	33·333	1·73	15	13·68	0·01	0·876	0·5076143	102	6	670	0	501	35	0·5075033
139	7 23	34·847	1·73	14	13·61	0·01	0·876	0·5072788	102	5	667	0	531	35	0·5071652
137	8 17	34·401	1·73	14	13·61	0·01	0·876	0·5073743	102	5	667	0	520	35	0·5072618
													Mean	...	0·5072546
140	17 35	35·270	−1·73	16	12·05	+0·49	0·878	0·5071902	+102	−7	−590	+12	−532	−35	0·5070852
138	18 33	33·379	1·73	15	12·50	0·49	0·876	0·5076036	102	6	613	12	501	35	0·5074995
139	19 26	34·885	1·73	14	12·93	0·49	0·873	0·5072706	102	5	634	12	529	35	0·5071617
137	20 22	34·425	1·73	14	13·38	0·49	0·869	0·5073692	102	5	656	12	516	35	0·5072594
													Mean	...	0·5072515
									Time of Vibration of Mean Pendulum					...	**0·5072530**
	29-30 January, 1904.														
139	5 56	34·850	−1·66	15	13·64	−0·06	0·879	0·5072780	+97	−6	−668	−2	−533	−35	0·5071633
137	6 51	34·399	1·66	15	13·66	0·06	0·877	0·5073748	97	6	669	2	521	35	0·5072612
140	7 48	35·217	1·66	15	13·56	0·06	0·880	0·5072011	97	6	664	2	533	35	0·5070868
138	8 45	33·338	1·66	15	13·50	0·06	0·878	0·5076131	97	6	662	2	502	35	0·5075021
													Mean	...	0·5072534
139	17 47	34·899	−1·66	12	12·39	+0·52	0·880	0·5072678	+97	−4	−607	+13	−533	−35	0·5071609
137	18 48	35·586	1·66	14	12·84	0·52	0·878	0·5073663	97	5	629	13	522	35	0·5072582
140	19 48	35·235	1·66	15	13·38	0·52	0·874	0·5071972	97	6	656	13	530	35	0·5070855
138	20 47	33·340	1·66	15	13·94	0·52	0·871	0·5076126	97	6	683	13	498	35	0·5075014
													Mean	...	0·5072515
									Time of Vibration of Mean Pendulum					...	**0·5072525**
	3-4 February, 1904.														
138	6 10	33·367	−2·50	15	13·37	+0·06	0·879	0·5076065	+147	−6	−655	+1	−503	−35	0·5075014
140	7 3	35·249	2·50	14	13·44	0·06	0·878	0·5071946	147	5	659	1	532	35	0·5070863
137	8 0	34·439	2·50	15	13·51	0·06	0·878	0·5073661	147	6	662	1	522	35	0·5072584
139	8 55	34·883	2·50	16	13·53	0·06	0·878	0·5072710	147	7	663	1	532	35	0·5071621
													Mean	...	0·5072521
137	18 20	34·450	−2·50	14	13·01	+0·49	0·879	0·5073638	+147	−5	−637	+12	−522	−35	0·5072598
139	19 13	34·893	2·50	16	13·44	0·49	0·876	0·5072691	147	7	659	12	531	35	0·5071618
138	20 9	33·361	2·50	16	13·95	0·49	0·872	0·5076079	147	7	684	12	499	35	0·5075013
140	21 4	35·231	2·50	15	14·36	0·49	0·871	0·5071983	147	6	704	12	528	35	0·5070869
													Mean	...	0·5072525
									Time of Vibration of Mean Pendulum					...	**0·5072523**

Table I. Details of the Observations—(Continued).

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature		Density of Air	Observed Time of Vibration	Correction on account of						Reduced Time of Vibration
					Corrected Mean	Mean change per hour			Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	
							4·5 February, 1904.								
	h m	s	s	′	°	°		s							s
137	6 21	34·421	−2·45	15	13·70	−0·05	0·877	0·5073700	+144	−6	−671	−1	−521	−35	0·5072610
139	7 18	34·869	2·45	15	13·73	0·05	0·876	0·5072740	144	6	673	1	531	35	0·5071638
138	8 17	33·350	2·45	16	13·66	0·05	0·877	0·5076102	144	7	669	1	502	35	0·5075032
140	9 12	35·235	2·45	15	13·58	0·05	0·877	0·5071973	144	6	665	1	531	35	0·5070879
													Mean	...	0·5072540
140	18 25	35·269	−2·45	15	12·81	+0·52	0·877	0·5071905	+144	−6	−628	+13	−531	−35	0·5070862
138	19 23	33·375	2·45	15	13·26	0·52	0·876	0·5076046	144	6	650	13	501	35	0·5075011
139	20 23	34·886	2·45	14	13·83	0·52	0·872	0·5072705	144	5	678	13	528	35	0·5071616
137	21 48	34·416	2·45	15	14·52	0·52	0·868	0·5073711	144	6	711	13	516	35	0·5072600
													Mean	...	0·5072522
													Time of Vibration of Mean Pendulum	...	0·5072531
							5·6 February, 1904.								
140	6 23	35·221	−2·48	14	13·97	−0·04	0·878	0·5072003	+146	−5	−685	−1	−532	−35	0·5070891
138	7 27	33·345	2·48	16	14·03	0·04	0·878	0·5076115	146	7	687	1	502	35	0·5075029
139	8 21	34·868	2·48	15	13·96	0·04	0·878	0·5072743	146	6	684	1	532	35	0·5071631
137	9 14	34·420	2·48	14	13·88	0·04	0·879	0·5073702	146	5	680	1	522	35	0·5072605
													Mean	...	0·5072539
138	18 16	33·385	−2·48	14	12·94	+0·51	0·879	0·5076022	+146	−5	−634	+13	−503	−35	0·5075004
140	19 10	35·257	2·48	15	13·39	0·51	0·875	0·5071928	146	6	656	13	530	35	0·5070860
137	20 9	34·436	2·48	16	13·85	0·51	0·873	0·5073668	146	7	679	13	519	35	0·5072587
139	21 4	34·875	2·48	15	14·31	0·51	0·872	0·5072729	146	6	701	13	528	35	0·5071618
													Mean	...	0·5072517
													Time of Vibration of Mean Pendulum	...	0·5072528
							Madras.								
							3·4 March, 1904.								
	h m	s	s	′	°	°		s							s
137	10 24	33·111	+3·39	15	26·79	+0·01	0·900	0·5076662	−199	−6	−1313	0	−535	−39	0·5074570
139	11 15	33·511	3·39	16	26·87	0·01	0·900	0·5075733	199	7	1317	0	545	39	0·5073626
138	12 9	32·100	3·39	16	26·84	0·01	0·900	0·5079113	199	7	1315	0	515	39	0·5077038
140	13 1	33·837	3·39	15	26·86	0·01	0·901	0·5074993	199	6	1316	0	546	39	0·5072887
													Mean	...	0·5074530
137	22 29	33·106	+3·39	14	26·39	+0·14	0·900	0·5076673	−199	−5	−1293	+4	−535	−39	0·5074606
139	23 22	33·506	3·39	15	26·57	0·14	0·901	0·5075746	199	6	1302	4	546	39	0·5073658
138	0 21	32·091	3·39	16	26·71	0·14	0·898	0·5079136	199	7	1309	4	514	39	0·5077072
140	1 19	33·828	3·39	14	26·80	0·14	0·897	0·5075013	199	5	1313	4	544	39	0·5072917
													Mean	...	0·5074563
													Time of Vibration of Mean Pendulum	...	0·5074547
							4·5 March, 1904.								
137	10 28	33·090	+3·30	14	26·43	−0·04	0·901	0·5076710	−194	−5	−1295	−1	−535	−39	0·5074641
139	11 22	33·504	3·30	15	26·46	0·04	0·903	0·5075749	194	6	1297	1	547	39	0·5073665
138	12 17	32·103	3·30	17	26·40	0·04	0·903	0·5079106	194	8	1294	1	517	39	0·5077053
140	13 7	33·840	3·30	15	26·33	0·04	0·902	0·5074987	194	6	1290	1	547	39	0·5072910
													Mean	...	0·5074567
137	22 34	33·107	+3·30	14	25·76	+0·24	0·902	0·5076672	−194	−5	−1262	+6	−536	−39	0·5074642
139	23 26	33·525	3·30	16	26·06	0·24	0·901	0·5075701	194	7	1277	6	546	39	0·5073644
138	0 19	32·117	3·30	17	26·25	0·24	0·898	0·5079071	194	8	1286	6	514	39	0·5077036
140	1 13	33·845	3·30	15	26·42	0·24	0·898	0·5074973	194	6	1295	6	544	39	0·5072901
													Mean	...	0·5074556
													Time of Vibration of Mean Pendulum	...	0·5074562

Table I. Details of the Observations—(Continued).

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature		Density of Air	Observed Time of Vibration	Correction on account of						Reduced Time of Vibration
					Corrected Mean	Mean change per hour			Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	
	6-7 March, 1904.														
	h m	s	s	′	°	°		s							s
137	10 47	33·120	+3·27	14	25·72	−0·08	0·904	0·5076641	−192	−5	−1260	− 2	− 537	−39	0·5074606
139	12 5	33·533	3·27	16	25·76	0·08	0·904	0·5075682	192	7	1262	2	548	39	0·5073632
138	13 19	32·128	3·27	17	25·62	0·08	0·905	0·5079043	192	8	1255	2	518	39	0·5077029
140	14 26	33·873	3·27	17	25·50	0·08	0·905	0·5074911	192	8	1250	2	548	39	0·5072872
													Mean	...	0·5074535
137	22 43	33·133	+3·27	17	25·52	+0·25	0·903	0·5076610	−192	−8	−1250	+ 6	− 536	−39	0·5074591
139	23 59	33·525	3·27	18	25·91	0·25	0·901	0·5075700	192	9	1270	6	546	39	0·5073650
138	1 9	32·097	3·27	17	26·17	0·25	0·900	0·5079122	192	8	1282	6	515	39	0·5077092
140	2 21	33·820	3·27	16	26·39	0·25	0·898	0·5075031	192	7	1293	6	544	39	0·5072962
													Mean	...	0·5074574
													Time of Vibration of Mean Pendulum	...	**0·5074555**
	7-8 March, 1904.														
137	10 25	33·123	+2·62	15	25·80	−0·06	0·904	0·5076633	−154	−6	−1264	− 2	−537	−39	0·5074631
139	11 15	33·533	2·62	16	25·85	0·06	0·904	0·5075682	154	7	1267	2	548	39	0·5073665
138	12 9	32·128	2·62	16	25·78	0·06	0·905	0·5079042	154	7	1263	2	518	39	0·5077059
140	13 3	33·869	2·62	15	25·66	0·06	0·906	0·5074921	154	7	1257	2	549	39	0·5072913
													Mean	...	0·5074567
137	22 36	33·147	+2·62	15	25·32	+0·32	0·905	0·5076577	−154	−6	−1241	+ 8	−538	−39	0·5074607
139	23 28	33·558	2·62	16	25·70	0·32	0·904	0·5075626	154	7	1259	8	548	39	0·5073627
138	0 21	32·138	2·62	14	25·97	0·32	0·902	0·5079020	154	5	1273	8	516	39	0·5077041
140	1 15	33·864	2·62	14	26·20	0·32	0·900	0·5074932	154	5	1284	8	545	39	0·5072913
													Mean	...	0·5074547
													Time of Vibration of Mean Pendulum	...	**0·5074557**
	Colaba Observatory.														
	16-17 March, 1904.														
	h m	s	s	′	°	°		s							s
137	9 58	33·558	+0·43	15	26·21	−0·09	0·899	0·5075623	− 25	−6	−1284	− 2	− 534	−38	0·5073734
139	10 56	33·988	0·43	15	26·10	0·09	0·899	0·5074653	25	6	1279	2	545	38	0·5072758
138	11 54	32·540	0·43	16	26·01	0·09	0·901	0·5078028	25	7	1274	2	515	38	0·5076167
140	12 49	34·335	0·43	15	25·94	0·09	0·899	0·5073890	25	6	1271	2	545	38	0·5072003
													Mean	...	0·5073666
137	22 1	33·585	+0·43	15	25·68	+0·39	0·900	0·5075563	− 25	−6	−1258	+ 10	− 535	−38	0·5073711
139	22 56	34·000	0·43	16	26·08	0·39	0·896	0·5074626	25	7	1278	10	543	38	0·5072745
138	23 51	32·552	0·43	16	26·41	0·39	0·895	0·5077999	25	7	1294	10	512	38	0·5076133
140	0 43	34·332	0·43	15	26·74	0·39	0·894	0·5073896	25	6	1310	10	542	38	0·5071985
													Mean	...	0·5073644
													Time of Vibration of Mean Pendulum	...	**0·5073655**
	17-18 March, 1904.														
140	10 0	34·331	+0·99	15	26·01	−0·05	0·901	0·5073898	− 58	−6	−1274	− 1	− 546	−38	0·5071975
138	10 54	32·538	0·99	16	25·98	0·05	0·901	0·5078031	58	7	1273	1	515	38	0·5076139
139	11 54	33·989	0·99	14	25·94	0·05	0·899	0·5074652	58	5	1271	1	545	38	0·5072734
137	12 50	33·560	0·99	15	25·87	0·05	0·899	0·5075618	58	6	1268	1	534	38	0·5073713
													Mean	...	0·5073640
140	22 6	34·342	+0·99	15	25·62	+0·38	0·900	0·5073872	− 58	−6	−1255	+ 9	− 545	−38	0·5071979
138	23 1	32·543	0·99	16	25·99	0·38	0·898	0·5078020	58	7	1274	9	514	38	0·5076138
139	23 55	33·981	0·99	15	26·32	0·38	0·895	0·5074668	58	6	1290	9	542	38	0·5072743
137	0 52	33·547	0·99	15	26·66	0·38	0·894	0·5075650	58	6	1306	9	531	38	0·5073720
													Mean	...	0·5073645
													Time of Vibration of Mean Pendulum	...	**0·5073643**

Table I. Details of the observations—(Continued).

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
20-21 March, 1904.															
	h m	s	s	′	°	°		s							s
139	10 4	33·993	+0·56	16	25·85	−0·11	0·903	0·5074643	− 33	−7	−1267	− 3	− 547	−38	0·5072748
137	11 5	33·571	0·56	15	25·75	0·11	0·903	0·5075596	33	6	1262	3	536	38	0·5073718
140	12 8	34·344	0·56	15	25·62	0·11	0·903	0·5073870	33	6	1255	3	547	38	0·5071988
138	13 4	32·556	0·56	16	25·56	0·11	0·902	0·5077988	33	7	1252	3	516	38	0·5076139
													Mean	...	0·5073648
139	22 21	34·025	+0·56	16	25·35	+0·51	0·902	0·5074571	− 33	−7	−1242	+ 13	− 547	−38	0·5072717
137	23 29	33·595	0·56	14	25·67	0·51	0·901	0·5075542	33	5	1258	13	535	38	0·5073686
140	0 26	34·352	0·56	17	26·20	0·51	0·895	0·5073852	33	8	1284	13	542	38	0·5071960
138	1 21	32·541	0·56	15	26·61	0·51	0·895	0·5078026	33	6	1304	13	512	38	0·5076146
													Mean	...	0·5073627
													Time of Vibration of Mean Pendulum	...	**0·5073638**
21-22 March, 1904.															
138	10 6	32·544	+0·80	15	25·94	−0·08	0·902	0·5078018	− 47	−6	−1271	− 2	− 516	−38	0·5076138
140	10 58	34·334	0·80	15	25·91	0·08	0·900	0·5073891	47	6	1270	2	545	38	0·5071983
137	11 57	33·564	0·80	15	25·83	0·08	0·900	0·5075611	47	6	1266	2	535	38	0·5073717
139	12 52	33·996	0·80	17	25·73	0·08	0·902	0·5074637	47	8	1261	2	547	38	0·5072734
													Mean	...	0·5073643
138	22 19	32·561	+0·80	15	25·23	+0·37	0·904	0·5077977	− 47	−6	−1236	+ 9	− 517	−38	0·5076142
140	23 13	34·348	0·80	14	25·58	0·37	0·903	0·5073860	47	6	1253	9	547	38	0·5071978
137	0 10	33·578	0·80	16	25·94	0·37	0·900	0·5075596	47	7	1271	9	535	38	0·5073707
139	1 6	33·995	0·80	16	26·27	0·37	0·897	0·5074637	47	7	1287	9	544	38	0·5072723
													Mean	...	0·5073638
													Time of Vibration of Mean Pendulum	...	**0·5073641**
Mussooree (*Dunseverick*).															
22-23 April, 1904.															
	h m	s	s	′	°	°		s							s
137	12 1	33·789	+8·50	16	16·19	+0·13	0·722	0·5075100	−499	−7	− 793	+ 3	− 429	−41	0·5073334
139	12 57	34·217	8·50	17	16·41	0·13	0·721	0·5074146	499	8	804	3	437	41	0·5072360
138	13 55	32·743	8·50	16	16·52	0·13	0·721	0·5077537	499	7	809	3	412	41	0·5075772
140	14 51	34·553	8·50	16	16·56	0·13	0·721	0·5073413	499	7	811	3	437	41	0·5071621
													Mean	...	0·5073272
137	0 1	33·798	+8·50	18	16·12	+0·11	0·722	0·5075079	−499	−9	− 790	+ 3	− 429	−41	0·5073314
139	0 57	34·228	8·50	17	16·33	0·11	0·721	0·5074122	499	7	800	3	437	41	0·5072341
138	1 51	32·754	8·50	17	16·40	0·11	0·721	0·5077510	499	8	804	3	412	41	0·5075749
140	2 47	34·569	8·50	17	16·47	0·11	0·720	0·5073380	499	8	807	3	436	41	0·5071592
													Mean	...	0·5073249
													Time of Vibration of Mean Pendulum	...	**0·5073261**
23-24 April, 1904.															
140	12 1	34·562	+8·17	17	16·61	+0·14	0·719	0·5073397	−480	−8	− 814	+ 3	− 436	−41	0·5071621
138	12 58	32·740	8·17	17	16·87	0·14	0·719	0·5077542	480	8	827	3	411	41	0·5075778
139	13 55	34·204	8·17	16	16·94	0·14	0·718	0·5074176	480	7	830	3	435	41	0·5072386
137	14 52	33·769	8·17	17	17·08	0·14	0·718	0·5075146	480	8	837	3	426	41	0·5073357
													Mean	...	0·5073286
140	0 20	34·570	+8·17	18	16·64	+0·08	0·721	0·5073378	−480	−9	− 815	+ 2	− 437	−41	0·5071598
138	1 13	32·751	8·17	17	16·77	0·08	0·720	0·5077517	480	8	822	2	412	41	0·5075756
139	2 6	34·223	8·17	18	16·82	0·08	0·720	0·5074133	480	9	824	2	436	41	0·5072345
137	3 2	33·786	8·17	17	16·90	0·08	0·720	0·5075106	480	8	828	2	428	41	0·5073323
													Mean	...	0·5073255
													Time of Vibration of Mean Pendulum	...	**0·5073271**

Table I. Details of the Observations—(Continued).

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature		Density of Air	Observed Time of Vibration	Correction on account of						Reduced Time of Vibration
					Corrected Mean	Mean change per hour			Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	
25-26 April, 1904.															
	h m	s	s	′	°	°		s							s
139	12 11	34·225	+7·73	18	16·83	+0·14	0·723	0·5074129	−454	−9	−825	+4	−438	−41	0·5072366
137	13 5	33·786	7·73	17	17·04	0·14	0·722	0·5075107	454	8	835	4	429	41	0·5073344
140	14 2	34·560	7·73	18	17·15	0·14	0·722	0·5073400	454	9	840	4	438	41	0·5071622
138	14 56	34·932	7·73	16	17·25	0·14	0·722	0·5077525	454	7	845	4	413	41	0·5075769
													Mean	...	0·5073275
139	0 29	34·226	+7·73	18	16·82	+0·12	0·724	0·5074127	−454	−9	−824	+3	−439	−41	0·5072363
137	1 25	33·792	7·73	16	17·01	0·12	0·724	0·5075093	454	7	833	3	430	41	0·5073331
140	2 22	34·565	7·73	17	17·10	0·12	0·723	0·5073388	454	7	838	3	438	41	0·5071613
138	3 16	32·751	7·73	15	17·18	0·12	0·722	0·5077518	454	6	842	3	413	41	0·5075765
													Mean	...	0·5073268
								Time of Vibration of Mean Pendulum						...	**0·5073272**
26-27 April, 1904.															
138	12 14	32·753	+7·73	15	17·12	+0·12	0·723	0·5077513	−454	−6	−839	+3	−414	−41	0·5075762
140	13 9	34·559	7·73	16	17·37	0·12	0·723	0·5073403	454	7	851	3	438	41	0·5071615
137	14 7	33·779	7·73	16	17·46	0·12	0·724	0·5075123	454	7	856	3	430	41	0·5073338
139	15 4	34·211	7·73	15	17·49	0·12	0·723	0·5074158	454	6	857	3	438	41	0·5072365
													Mean	...	0·5073270
138	0 25	34·941	+7·73	18	16·93	+0·16	0·726	0·5077503	−454	−9	−830	+4	−415	−41	0·5075758
140	1 24	34·566	7·73	15	17·18	0·16	0·725	0·5073387	454	5	842	4	439	41	0·5071610
137	2 24	33·788	7·73	13	17·28	0·16	0·724	0·5075102	454	5	847	4	430	41	0·5073329
139	3 16	34·221	7·73	16	17·42	0·16	0·723	0·5074137	454	7	854	4	438	41	0·5072347
													Mean	...	0·5073261
								Time of Vibration of Mean Pendulum						...	**0·5073266**
Mussooree Camel's Back (*Basevi's Station*).															
16-17 May, 1904.															
	h m	s	s	′	°	°		s							s
138	14 4	32·839	+6·93	17	14·54	−0·01	0·733	0·5077308	−407	−8	−712	0	−419	−37	0·5075725
140	14 58	34·662	6·93	16	14·60	0·01	0·733	0·5073180	407	7	715	0	444	37	0·5071570
137	15 57	33·876	6·93	17	14·56	0·01	0·735	0·5074905	407	8	713	0	437	37	0·5073303
139	16 52	34·309	6·93	15	14·56	0·01	0·736	0·5073946	407	6	713	0	446	37	0·5072337
													Mean	...	0·5073234
138	2 16	32·838	+6·93	17	14·43	+0·09	0·733	0·5077308	−407	−8	−707	+2	−419	−37	0·5075732
140	3 8	34·664	6·93	17	14·60	0·09	0·733	0·5073177	407	8	715	2	444	37	0·5071568
137	4 10	33·876	6·93	14	14·70	0·09	0·733	0·5074905	407	5	720	2	435	37	0·5073303
139	5 6	34·308	6·95	15	14·69	0·09	0·733	0·5073949	407	6	720	2	444	37	0·5072337
													Mean	...	0·5073235
								Time of Vibration of Mean Pendulum						...	**0·5073234**
17-18 May, 1904.															
139	13 48	34·344	+6·94	15	13·69	+0·13	0·737	0·5073868	−407	−6	−671	+3	−447	−37	0·5072303
137	14 42	33·893	6·94	14	13·90	0·13	0·736	0·5074866	407	5	681	3	437	37	0·5073302
140	15 41	34·685	6·94	15	13·99	0·13	0·736	0·5073131	407	6	686	3	446	37	0·5071552
138	16 34	32·851	6·94	17	14·08	0·13	0·734	0·5077278	407	8	690	3	420	37	0·5075719
													Mean	...	0·5073219
139	2 6	34·355	+6·94	16	13·46	+0·20	0·734	0·5073843	−407	−7	−660	+5	−445	−37	0·5072292
137	3 6	33·902	6·94	15	13·72	0·20	0·734	0·5074847	407	6	672	5	436	37	0·5073294
140	4 1	34·687	6·94	15	13·91	0·20	0·734	0·5073128	407	6	682	5	445	37	0·5071556
138	4 58	32·855	6·94	16	14·03	0·20	0·733	0·5077267	407	7	687	5	419	37	0·5075715
													Mean	...	0·5073214
								Time of Vibration of Mean Pendulum						...	**0·5073217**

Table I. Details of the Observations—(Continued).

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
							18-19 May, 1904.								
	h m	s	s	′	°	°		s							s
137	13 54	33·907	+7·10	15	14·16	+0·13	0·731	0·5074835	−417	−6	−694	+3	−434	−37	0·5073250
139	14 54	34·317	7·10	15	14·44	0·13	0·732	0·5073927	417	6	708	3	444	37	0·5072318
138	15 54	32·842	7·10	17	14·48	0·13	0·731	0·5077300	417	8	710	3	418	37	0·5075713
140	16 51	34·661	7·10	14	14·60	0·13	0·731	0·5073183	417	5	715	3	443	37	0·5071569
													Mean	...	0·5073213
137	2 15	33·894	+7·10	14	14·21	+0·18	0·731	0·5074862	−417	−5	−696	+5	−434	−37	0·5073278
139	3 15	34·319	7·10	16	14·42	0·18	0·730	0·5073923	417	7	707	5	442	37	0·5072318
138	4 12	32·841	7·10	18	14·59	0·18	0·730	0·5077301	417	9	715	5	418	37	0·5075710
140	5 7	34·664	7·10	15	14·72	0·18	0·730	0·5073177	417	6	721	5	442	37	0·5071559
													Mean	...	0·5073216
								Time of Vibration of Mean Pendulum						...	**0·5073214**
							Dehra Dun—(*Basevi's Station*).								
							27-28 May, 1904.								
	h m	s	s	′	°	°		s							s
137	14 37	34·130	−2·34	14	28·18	−0·11	0·822	0·5074338	+137	−5	−1381	−3	−488	−29	0·5072569
139	15 34	34·575	2·34	14	28·14	0·11	0·822	0·5073367	137	5	1379	3	498	29	0·5071590
138	16 33	33·075	2·34	14	28·02	0·11	0·823	0·5076746	137	5	1373	3	471	29	0·5075002
140	17 35	34·923	2·34	15	27·86	0·11	0·823	0·5072626	137	6	1365	3	499	29	0·5070861
													Mean	...	0·5072506
137	2 45	34·124	−2·34	13	28·10	+0·42	0·819	0·5074352	+137	−5	−1377	+11	−486	−29	0·5072603
139	3 41	34·563	2·34	15	28·57	0·42	0·817	0·5073393	137	6	1400	11	495	29	0·5071611
138	4 40	33·066	2·34	13	28·96	0·42	0·814	0·5076768	137	5	1419	11	466	29	0·5074997
140	5 35	34·905	2·34	15	29·31	0·42	0·813	0·5072663	137	6	1436	11	493	29	0·5070847
													Mean	...	0·5072514
								Time of Vibration of Mean Pendulum						...	**0·5072510**
							28-29 May, 1904.								
140	14 36	34·907	−2·34	16	28·57	−0·24	0·822	0·5072658	+137	−7	−1400	−6	−498	−29	0·5070855
138	15 37	33·055	2·34	12	28·41	0·24	0·824	0·5076795	137	4	1392	6	471	29	0·5075030
139	16 38	34·550	2·34	17	28·16	0·24	0·822	0·5073421	137	8	1380	6	498	29	0·5071637
137	17 33	34·104	2·34	15	27·90	0·24	0·824	0·5074397	137	6	1367	6	489	29	0·5072637
													Mean	...	0·5072540
140	2 53	34·914	−2·34	15	28·46	+0·33	0·819	0·5072647	+137	−6	−1395	+8	−496	−29	0·5070866
138	3 48	33·058	2·34	17	28·84	0·33	0·818	0·5076786	137	8	1413	8	468	29	0·5075013
139	4 42	34·546	2·34	15	29·15	0·33	0·817	0·5073430	137	6	1428	8	495	29	0·5071617
137	5 41	34·099	2·34	14	29·38	0·33	0·816	0·5074407	137	5	1440	8	485	29	0·5072593
													Mean	...	0·5072522
								Time of Vibration of Mean Pendulum						...	**0·5072531**
							2-3 June, 1904.								
137	15 3	33·973	+2·90	15	28·21	−0·24	0·826	0·5074687	−170	−6	−1382	−6	−491	−29	0·5072603
139	16 1	34·409	2·90	16	27·91	0·24	0·827	0·5073727	170	7	1368	6	501	29	0·5071646
138	16 58	32·933	2·90	14	27·65	0·24	0·828	0·5077081	170	5	1355	6	474	29	0·5075042
140	17 53	34·773	2·90	14	27·54	0·24	0·827	0·5072946	170	5	1349	6	501	29	0·5070886
													Mean	...	0·5072544
137	3 0	33·985	+2·90	14	28·63	−0·06	0·819	0·5074660	−170	−5	−1403	−2	−486	−29	0·5072565
139	3 53	34·415	2·90	16	28·88	0·06	0·820	0·5073713	170	7	1415	2	497	29	0·5071593
138	4 54	32·927	2·90	16	28·58	0.06	0·823	0·5077096	170	7	1400	2	471	29	0·5075017
140	5 50	34·763	2·90	14	28·69	0·06	0·820	0·5072963	170	5	1406	2	497	29	0·5070854
													Mean	...	0·5072507
								Time of Vibration of Mean Pendulum						...	**0·5072526**

Table I. Details of the Observations—(Continued).

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature		Density of Air	Observed Time of Vibration	Correction on account of						Reduced Time of Vibration
					Corrected Mean	Mean change per hour			Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	
							3·4 June, 1904.								
	h m	s	s	′	°	°		s							s
140	15 0	34·778	+2·99	14	27·74	−0·26	0·826	0·5072932	−176	−5	−1359	− 6	− 501	−29	0·5070856
138	15 57	32·948	2·99	15	27·49	0·26	0·827	0·5077047	176	6	1347	6	473	29	0·5075010
139	16 52	34·436	2·99	16	27·24	0·26	0·827	0·5073667	176	7	1335	6	501	29	0·5071613
137	17 47	34·011	2·99	15	27·02	0·26	0·828	0·5074601	176	6	1324	6	492	29	0·5072568
													Mean	...	0·5072512
140	3 6	34·776	+2·99	15	28.39	+0·52	0·818	0·5072937	−176	−6	−1391	+ 13	− 496	−29	0·5070852
138	4 7	32·930	2·99	16	28·95	0·52	0·814	0.5077090	176	7	1419	13	466	29	0·5075006
139	5 4	34·399	2.99	16	29·47	0·52	0·813	0·5073750	176	7	1444	13	493	29	0·5071614
137	6 6	33·947	2·99	16	29·94	0·52	0·811	0·5074745	176	7	1467	13	482	29	0·5072597
													Mean	...	0·5072517
									Time of Vibration of Mean Pendulum					...	**0·5072514**
							4-5 June, 1904.								
139	15 1	34·390	+3·43	15	28·80	−0·14	0·823	0·5073768	−201	−6	−1411	− 4	− 499	−29	0·5071618
137	15 58	33·956	3·43	14	28·48	0·14	0·823	0·5074726	201	5	1396	4	489	29	0·5072602
140	16 57	34·750	3·43	15	28·45	0·14	0·822	0·5072993	201	6	1394	4	498	29	0·5070861
138	17 54	32·923	3·43	16	28·28	0·14	0·823	0·5077108	201	7	1386	4	471	29	0·5075010
													Mean	...	0·5072523
139	3 13	34·403	+3·43	15	29·16	+0·43	0·814	0·5073740	−201	−6	−1429	+ 11	− 493	−29	0·5071593
137	4 7	33·953	3·43	15	29·62	0·43	0·813	0·5074731	201	6	1451	11	483	29	0·5072572
140	5 3	34·729	3·43	15	30·07	0·43	0·811	0·5073036	201	6	1473	11	491	29	0·5070847
138	6 4	32·888	3·43	14	30·43	0·43	0·810	0·5077190	201	5	1491	11	463	29	0·5075012
													Mean	...	0·5072506
									Time of Vibration of Mean Pendulum					...	**0·5072515**

The value of g at Dehra Dun.

As Dehra Dún is to be the Base station for all the Indian Pendulum work, a value of g must be adopted for it in terms of which g at all other stations shall be expressed.

At Kew, where the value 981·200 has been accepted, we have (*Vide* Chap. I) the following times of vibration of the pendulums:—

Pendulum	137	138	139	140	Mean
Time of vibration	0·5067070	0·5069490	0·5066104	0·5065339	0·5067001

At Dehra Dún in January and February 1904, we have the following values:—

Table II. Time of Vibration at Dehra Dún.

Date	137	138	139	140	Mean
1904	s	s	s	s	s
January ... 25-26	0·5072600	0·5075013	0·5071630	0·5070870	0·5072528
„ ... 26-27	0·5072606	0·5075014	0·5071635	0·5070867	0·5072530
„ ... 29-30	0·5072597	0·5075018	0·5071621	0·5070862	0·5072525
February ... 3- 4	0·5072591	0·5075014	0·5071620	0·5070866	0·5072523
„ ... 4- 5	0·5072605	0·5075022	0·5071627	0·5070871	0·5072531
„ ... 5- 6	0·5072596	0·5075017	0·5071625	0·5070876	0·5072528
Mean ...	0·5072599	0·5075016	0·5071626	0·5070869	0·5072528
Diff. from Kew ...	5529	5526	5522	5530	5527

The May and June observations produced another set of values, namely:—

Table III. Time of Vibration at Dehra Dún.

Date	137	138	139	140	Mean
1904	s	s	s	s	s
May ... 27-29*	0·5072601	0·5075011	0·5071614	0·5070858	0·5072521
June ... 2- 3	0·5072584	0·5075030	0·5071620	0.5070870	0·5072526
„ ... 3- 4	0·5072582	0·5075008	0·5071613	0·5070854	0·5072514
„ ... 4- 5	0·5072587	0·5075011	0·5071606	0·5070854	0·5072515
Mean ...	0·5072589	0·5075015	0·5071613	0·5070859	0·5072519
Diff. from Kew ...	5519	5525	5509	5520	5518

There is thus a difference of $9^s \times 10^{-7}$ between the reduced times of vibration of the mean pendulum as determined by the first and second series of observations respectively.

For the deduction of g the first series of values will be used, firstly because these observations were made immediately after the arrival of the pendulums in India, so that there is less probability of any change having taken place in the lengths of the pendulums, and secondly because the average temperature during the January and February swings was very nearly the same as it had been at Kew, whereas during the May and June swings it was much higher.

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* As no stars were observed on May 28th the Pendulum observations of 27th, 28th and 29th are treated as one set.

The actual mean temperatures were:—

At Kew (taking account of the combination-weights of the several series of observations) ... ... 14°·1 C

At Dehra Dún in January and February ... 13·4 „

At Dehra Dún in May and June ... 28·5 „

The coefficient of the temperature correction is $49^{s} \times 10^{-7}$: an error of one per cent in this number would thus produce a difference of about $8^{s} \times 10^{-7}$ between the two values of the time of vibration found at Dehra Dún.

Computing by the formula

$$s^2_0\, g_0 = s^2\, g$$

and using the figures of Table II, we have for the value of g at Dehra Dún:—

Pendulum	137	138	139	140
g at Dehra Dún	979·062	979·064	979·064	979·061

Mean Value of g at Dehra Dun ... ... 979·063

For the present the value **979·063** will be adopted, but the determination cannot be considered complete until the pendulums have been taken back to Kew and swung there again.

Values of g at the other stations of 1904.

For the computation of g at the other stations the mean of the two sets of times of vibration at Dehra Dún will be employed.

Table IV. Deduction of g.

Pendulum	137	138	139	140	Mean
			Dehra Dun.		
Time of vibration	s 0·5072594	s 0·5075016	s 0·5071620	s 0·5070864	s 0·5072524
			Madras.		
Time of vibration	0·5074612	0·5077053	0·5073646	0·5072910	0·5074555
Difference from Dehra Dún	+2018	+2037	+2026	+2046	+2031
g	978·284	978·277	978·281	978·273	978·279
			Colaba.		
Time of vibration	0·5073714	0·5076143	0·5072738	0·5071981	0·5073644
Difference from Dehra Dún	+1120	+1127	+1118	+1117	+1120
g	978·631	978·628	978·631	978·631	978·631
			Mussooree *(Dunseverick).*		
Time of vibration	0·5073334	0·5075764	0·5072359	0·5071612	0·5073267
Difference from Dehra Dún	+740	+748	+739	+748	+743
g	978·777	978·774	978·777	978·773	978.776
			Mussooree *(Camel's Back).*		
Time of vibration	0·5073288	0·5075719	0·5072318	0·5071562	0·5073222
Difference from Dehra Dún	+694	+703	+698	+698	+698
g	978·795	978·791	978·793	978·793	978·793

The agreement between the results by the different pendulums is on the whole satisfactory, and there is no evidence of a change in the length of any of the pendulums which could not with equal probability be ascribed to accidental error.

Comparison with Theoretical Values.

In Chapter I the steps that have to be taken in order to find the value of the force of gravity at a point above the sea level in a given latitude are enumerated, and the theoretical value, based on an acceleration of 978·000 C. G. S. at sea level at the Equator, was deduced both for Kew and Greenwich, using Mr. Strahan's analysis of the underlying strata. In India it will, at any rate for the present, be more convenient to assume that all masses and strata have a density of 2·8, *i.e.* the mean surface density, and by comparing the observed and computed values of the force of gravity, to ascertain where the actual density exceeds or falls short of this mean.

The difference between the observed and computed values of gravity is therefore the number that we are in search of.

It obviously leads to the same result whether we take the theoretical value for the latitude in question and apply corrections to allow for the height of the station above sea level, or apply these corrections with reversed signs to the observed value and so obtain a number which can be compared with the theoretical value at sea level.

The second is the more convenient procedure, as we thus obtain a series of normal values increasing with the latitude, and independent of the heights of the stations.

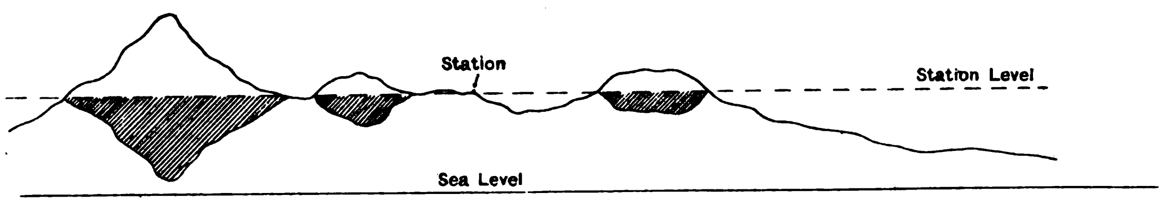
The Orographical Correction.

Correction No. 4 of Chapter I — the orographical correction—must now be dealt with.

The question has been very fully gone into in Volume V of *The Account of the Operations of the G. T. Survey of India,* and the elaborate computation of the correction for Basevi's Mussooree station is given in detail.

The method of treatment which I have adopted is that shewn in para. 6 on p. [187] of the above mentioned volume, but I have throughout first applied the correction which would be appropriate if the station was situated on an infinite plain, and then computed the effect of the inequality of the surface and applied it as a secondary correction. This plan has the advantage that the station is situated in the plane of the upper surface of every zone or block which has to be considered, and this renders the calculations of the attractions very simple.

Masses which stand above the horizontal plane through the station have been imagined to cancel equal masses below it, and thus the station has always been made the highest point of the region, except indeed where it was simpler, as in the case of stations at the foot of hills, to consider that all masses were standing above this plane. The computation is precisely the same in both cases.



In the diagram the shaded portions shew the masses whose attraction on the station is imagined cancelled by that of the hill tops standing above the infinite plain.

The formula employed is the ordinary one for the attraction of a cylinder upon a point in its axis, namely :—

$$A = 2\pi G\theta \left\{h + \sqrt{r^2+c^2} - \sqrt{r^2 + (h+c)^2}\right\}$$

where
G = acceleration due to the attraction of unit mass at unit distance
θ = density of mass
r = radius of cylinder
h = height of cylinder
c = height of attracted point above the cylinder's upper surface.

Hence the attraction of a hollow cylinder of which the inner radius is r_1, the outer r_2, and the height h, on a point situated in its axis and in the plane of its upper surface is

$$Z = 2\pi G\theta \left\{r_2 - r_1 - \left(\sqrt{r_2^2 + h^2} - \sqrt{r_1^2 + h^2}\right)\right\}$$

The attraction of a sphere of radius R and density θ' on a point on its surface is $\frac{4}{3}\pi G \theta' R$, which in the case of the earth is called g.

Hence $$\frac{Z}{g} = \frac{3}{2} \cdot \frac{\theta}{\theta'} \cdot \frac{1}{R}\left\{r_2 - r_1 - \left(\sqrt{r_2^2 + h^2} - \sqrt{r_1^2 + h^2}\right)\right\}$$

and putting $\frac{\theta}{\theta'} = \frac{1}{2}$, R = 20,900,000 ft. and g = 978 *cm*

$$Z = 0\cdot000035 \left\{r_2 - r_1 - \left(\sqrt{r_2^2 + h^2} - \sqrt{r_1^2 + h^2}\right)\right\} \quad . \; . \; . \quad (1)$$

Expanding the roots the expression in brackets becomes

$$\frac{1}{2}h^2\left(\frac{1}{r_1} - \frac{1}{r_2}\right) - \frac{1}{8}h^4\left(\frac{1}{r_1^3} - \frac{1}{r_2^3}\right) + \&c.$$

If the second term is not greater than about 2 per cent of the first it may be neglected. When r is equal to $5h$ this condition will ordinarily be satisfied, even where the slopes are very steep.

For the immediate neighbourhood, therefore, of the stations of observation formula (1) has been used, and for the more distant parts

$$Z = 0\cdot000035 \times \frac{1}{2}h^2\left(\frac{1}{r_1} - \frac{1}{r_2}\right) \quad . \; . \; . \; . \; . \; . \; . \; . \quad (2)$$

The Division of the Region into Zones.

No fixed rule has been followed in deciding upon the radii of the successive zones, much depends upon the maps available and upon the steepness of the slopes in the neighbourhood of the station.

If only small scale maps are available, or if the immediate surroundings of the station are fairly level, it is useless to divide up the region into narrow zones.

Mussooree (Dunseverick) was the first station for which the orographical correction had to be computed and I adopted nearly the same radii as Captain Basevi had used in dealing with his station. Some of his radii gave very awkward quantities, and as they possessed no important advantages I abandoned them for round numbers of feet or miles. The number of zones is certainly unnecessarily large and I kept them for the sake of being able to make a comparison between his method of computing and that which I have adopted, and also in order to see whether my estimation of heights would in any degree accord with his. The maps of the country to the north of Mussooree are extremely defective and the estimation of mean heights was mere guess-work, so there was room for wide divergence of opinion.

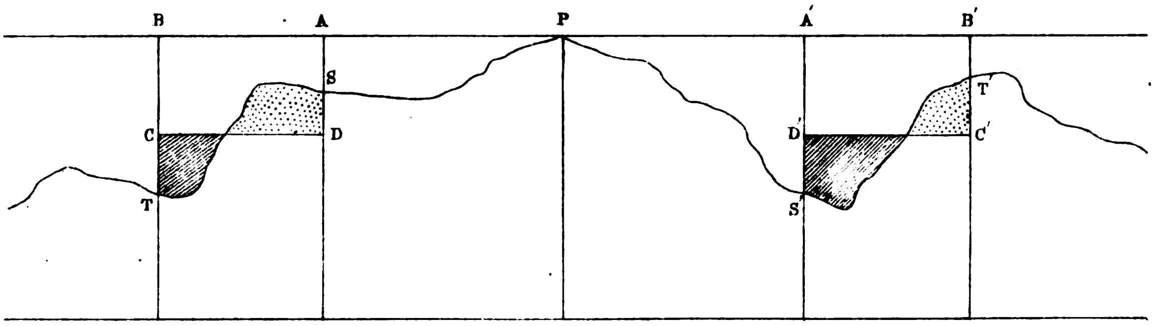
Captain Basevi broke up his zones into blocks by drawing radii at 20° intervals up to a radius of 1320 feet, and thereafter at 10° intervals, thus making 18 and 36 portions respectively; I considered this a needlessly large number and divided my zones into 8 blocks up to a radius of 500 feet, into 12 from 500 feet to 1600 feet, into 16 from 1600 feet to 3 miles, and into 24 from 3 miles to the limits of the investigation.

The mean height of each block was estimated by the best means at hand, but outside a radius of 2 miles a considerable portion of each zone lay in country of which only small scale maps exist. These maps contain very few heights and those that there are almost always refer to peaks, so that the general level is extremely difficult even to guess at.

Estimating the heights of the blocks is by far the longest part of the operation, but even after this has been done the computation, so long as formula (1) has to be used, is sufficiently tedious.

Strictly speaking the effect of each block should be computed and the mean taken: it is not correct to take the mean height of the zone and compute the attraction of the resulting cylinder. This is easily seen from the formula, for $\frac{1}{n}\Sigma h^2$ is not $= h_0^2$, where h_0 is the mean of n values of h; the physical meaning is that when we imagine a zone brought to its mean height by levelling, the process implied is the cutting off of all the heights and the filling up of the hollows, thus all the high masses are placed at a lower level and none at a higher. Clearly, the more nearly under the attracted point a mass is, the greater will be the vertical component of its attraction, thus a levelled zone exerts a greater vertical attraction than the natural zone.

The diagram illustrates this: it represents a section through a pendulum station P.



We desire to compute the attraction of the zone enclosed between circles of radius P A and P B respectively, that is to say of the irregular cylindrical mass which is seen in section at

A S T B and A′ S′ T′ B′. If C D D′ C′ be the surface when the irregularities are all levelled up, we see that we have in effect cut off the two speckled heights and filled up the shaded hollows, and clearly, as far as height is concerned, the shaded portions are more favourably placed for exerting a vertical attraction on P than are the speckled ones. It is true that in the left hand portion the speckled mass has been removed to a greater distance, and that in that respect its effect has been reduced, but the reverse is the case in the right hand portion, and on the whole the lateral displacements will as often be inwards as outwards and no systematic error will be produced.

Thus every time that we take a mean height we increase the vertical attraction of the masses standing on sea level, and decrease that of the difference between the actual mass and the corresponding portion of the cylinder bounded by sea level and by a horizontal plane through the station; that is to say, when we take A B C D instead of A B T S the substitution always involves a loss of efficiency.

In the diagram P is the highest point: to consider the case of a valley station we have only to turn the section upside down; then the masses we have to deal with are those that lie above the plane of the station; here the shaded portions are supposed to be cut off and the speckled ones filled in, which has the effect of reducing the vertical attraction of the mass; that is to say, as before, A B C D is less efficient than A B T S.

The removal of a mass from its actual position to one at the same distance but in any other azimuth has no effect on the vertical component of its attraction, and we may therefore make imaginary displacements of this sort to any extent. I have used this fact in abbreviating the computation of the attraction of those zones for which formula (2) cannot be used.

The method has been to arrange the blocks in order of elevation and then divide them into four equal groups; I have then taken the mean elevation of each group and computed the attraction of the levelled quarter-zones so formed.

This has reduced the labour by one-half in the case of the first 6 zones, by two-thirds in zones 7 to 14, by three-fourths in 15 to 29 and by five-sixths in the remainder, and, as by this means very large vertical displacements have been avoided, a fair approximation to the truth has been obtained.

Limits of the Investigation.

It will be observed that the investigation has not been carried beyond a radius of 35 miles. In Basevi's calculation the enquiry is carried to much greater distances, but the advantage of this may be questioned, while the labour involved must be considerable.

Examining Basevi's figures (p. [173] of Vol. V. *Op. G. T. S.*) we see that the total effect of all the masses standing above sea level is

9·5536 vibrations per day.

If N be the number of vibrations per day made by his pendulums,

$$dg = \frac{2g}{N}\, dN$$

putting $g = 978$ and $N = 86012$

we have, if $dN = 9\cdot5536$,

$$\begin{aligned} dg &= 0\cdot02274 \times 9\cdot5536 \\ &= 0\cdot2171 \end{aligned}$$

Now the attraction of an infinite plain 6920 feet high is

$$g \times \frac{3}{4} \times \frac{h}{R} = 0\cdot2433$$

Hence the difference obtained, using all Basevi's zones, is

0·0262

If we omit the zones beyond 35 miles, taking a proportionate part of the zone between 29·4 and 37·6 miles, dN becomes 9·4318 and dg 0·2142, and the difference between this and the attraction of the infinite plain is

0·0291

Thus by omitting the outer zones a difference of 0·0029 in the orographical correction is produced.

This difference is not very large, its amount is not very certain and yet to obtain it a great deal of trouble must have been taken and many maps must have been examined.

If instead of analysing the country outside the 35-mile radius in detail, we look at it in a general way and assume that a plain 6920 feet high and of indefinite extension occupies the northern half, and that the southern half is all at sea level we shall obtain the following figures.

	cm
Attraction of infinite plain 6920 feet high all round	0·2433
,, ,, disc of same height 35 miles in radius	0·2378
Difference = attraction of plain outside 35-mile radius	0·0055
Half difference	0·0028
Attraction of 35-mile disc + half outer plain	0·2406
,, ,, actual masses within 35-mile radius	0·2142
Difference = orographical correction	0·0264
,, ,, by Basevi's analysis	0·0262

In this case therefore the approximate method is justified and it will in many instances be found possible to make some simple generalisation which will take sufficient account of all but the nearest masses.

The Effect of Curvature.

No account has so far been taken of the curvature of the earth's surface, nor is it intended to do so. The effect of applying the corrections which are under discussion is to produce a value of g at sea level which shall be comparable with γ_0 the theoretical value depending on the latitude; as we recede from the station the effect of the surface masses, conceived as lying on a plane tangential to the spheroid, becomes rapidly smaller, and at a distance of 100 miles* or so becomes insensible. Up to this distance the effect of the earth's curvature is inappreciable. Beyond this the curvature becomes the most important element in producing a vertical attraction at the station of observation, but the difference in the attraction of such distant masses on the station and on a point at sea level vertically below it is now so small as to be negligible, and it is this difference that is required when we are reducing to sea level. Hence neither for proximate nor for distant masses should the effect of curvature be taken into account.†

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* A block 1 mile high occupying 30° of a zone the inner radius of which is 100 miles and the outer infinite, exerts a vertical attraction of 0·000,077 C. G. S. on a station at sea level at the centre of the zone.

† Cf. Vol. V. *Op. G. T. S.* page [189] et. seq. and "Die Schwerkraft im Hochgebirge" by Prof. F. R. Helmert, p. 29.

The Orographical Correction at Mussooree (Dunseverick).

In Tables VI & VII, the figures relating to the orographical correction at Dunseverick are given. Δh is the difference between the height of the quarter-zone, formed according to the method explained above, and the height of the station. In the column with the heading "effect" is shewn the value of the quantity

$$\left\{r_2 - r_1 - \left(\sqrt{r_2^2 + \Delta h^2} - \sqrt{r_1^2 + \Delta h^2}\right)\right\}$$

this number when multiplied by 0·000035 gives the value of the attraction of a complete cylinder of height Δh, therefore the mean of the four "effects" is the measure of the sum of the attractions of the four quarter-cylinders.

After zone 31 the simpler formula (2) has been used and it has not been necessary to group the blocks, for the computation in full is quite short. Here the quantity "effect" has the same meaning as before: it is equal to

$$\frac{1}{2} \times \frac{\Delta h^2}{n} \times \left(\frac{1}{r_1} - \frac{1}{r_2}\right) \times 0{\cdot}0001894$$

The factor 0·0001894 is required because here r_1 and r_2 are expressed in miles.

Finally the sum of all the effects is taken, and this, multiplied by 0·000035, is the difference between the attraction of a disc 35 miles in radius and 7129 feet thick and the actual attraction of the existing masses within the same radius.

Table VI. Orographical Correction at Mussooree (Dunseverick). Height 7129 *feet.*

No. of Zone	Inner Radius	Outer Radius	Δh	Effect	Mean Effect
	feet	*feet*	*feet*		
1	150	200	5 39 51 58	0·0 1·2 2·0 2·6	1·5
2	200	250	26 49 76 96	0·4 1·1 2·7 4·0	2·1
3	250	300	31 61 96 129	0·3 1·2 2·8 4·7	2·3
4	300	350	46 84 121 161	0·5 1·6 3·2 5·2	2·6
5	350	400	56 119 146 201	0·6 2·4 3·4 5·9	3·1
6	400	500	84 151 199 258	1·7 5·3 8·7 13·3	7·3
7	500	600	78 186 236 336	1·0 5·3 8·2 14·7	7·3
8	600	700	93 194 264 379	1·1 4·2 7·4 13·7	6·6
9	700	800	96 209 313 441	0·9 3·6 7·8 13·7	6·5
10	800	900	119 235 369 499	1·0 3·6 8·3 13·9	6·7
11	900	1000	158 264 426 543	1·4 3·6 8·7 13·1	6·7
12	1000	1200	179 324 486 631	2·8 8·3 17·2 26·6	13·7
13	1200	1400	214 398 526 724	2·6 8·8 14·6 25·4	12·9
14	1400	1600	249 436 568 771	2·6 8·0 13·0 22·2	11·5
15	1600	1800	301 430 586 821	3·2 6·1 10·7 20·0	10·0
16	1800	2000	304 477 642 864	2·6 6·0 11·0 17·9	9·4
17	2000	2200	339 520 707 895	2·6 5·9 10·5 16·0	8·8
18	2200	2420	394 550 762 955	3·3 6·0 11·1 16·7	9·3
19	2420	2640 (½ mile)	425 599 831 1009	3·0 5·9 11·0 15·6	8·9
20	2640	3300 (⅝ mile)	478 682 967 1180	7·5 17·0 32·7 47·1	26·1
21	3300	3960 (¾ mile)	482 793 1155 1380	5·8 15·3 31·3 43·3	23·9
22	3960	4620 (⅞ mile)	573 830 1055 1430	5·8 12·1 19·2 34·1	17·8
23	4620	5280 (1 mile)	605 963 1242 1493	4·9 12·2 19·9 28·2	16·3
24	5280	6600 (1¼ miles)	830 1130 1405 1580	12·9 23·6 35·9 44·8	29·3
25	6600	7920 (1½ miles)	855 1255 1605 1880	9·2 19·5 31·4 42·4	25·6
26	7920	9240 (1¾ miles)	830 1455 1780 2205	6·2 18·6 27·7 41·8	23·6
27	9240	10560 (2 miles)	730 1430 2005 2555	3·6 13·6 26·4 42·2	21·5
28	10560	13200 (2½ miles)	580 1430 2680 3180	3·2 19·2 65·5 90·8	44·7
29	13200	15840 (3 miles)	480 1505 2855 3555	1·5 14·2 50·0 76·3	35·5
30	15840	21120 (4 miles)	1033 2000 2850 3783	8·4 31·2 63·0 109·4	53·0
31	21120	26400 (5 miles)	1200 1967 3033 4067	6·8 18·2 43·0 76·6	36·2

Table VII. Orographical Correction at Mussooree (Dunseverick).
Height 7129 *feet.*

Zone 32		Zone 33		Zone 34		Zone 35		Zone 36	
r_1	5 Miles	r_1	6 Miles	r_1	7 Miles	r_1	8½ Miles	r_1	10 Miles
r_2	6 "	r_2	7 "	r_2	8½ "	r_2	10 "	r_2	12 "
$\frac{1}{r_1}$	0·200	$\frac{1}{r_1}$	0·167	$\frac{1}{r_1}$	0·143	$\frac{1}{r_1}$	0·118	$\frac{1}{r_1}$	0·100
$\frac{1}{r_2}$	0·167	$\frac{1}{r_2}$	0·143	$\frac{1}{r_2}$	0·118	$\frac{1}{r_2}$	0·100	$\frac{1}{r_2}$	0·083
Δh	$(\Delta h)^2 \times 10^{-4}$	Δh	$(\Delta h)^2 \times 10^{-4}$	Δh	$(\Delta h)^2 \times 10^{-4}$	Δh	$(\Delta h)^2 \times 10^{-4}$	Δh	$(\Delta h)^2 \times 10^{-4}$
feet 800	64	*feet* 600	36	*feet* 2600	676	*feet* 2600	676	*feet* 1100	121
300	9	500	25	900	81	700	49	1100	121
1100	121	1300	169	700	49	1100	121	1500	225
2100	441	1600	256	1400	196	1400	196	600	36
1600	256	2100	441	1800	324	1400	196	1100	121
1300	169	1900	361	1700	289	1600	256	1400	196
800	64	800	64	800	64	700	49	700	49
1700	289	2100	441	300	9	1100	121	1300	169
2400	576	2900	841	1600	256	2600	676	1600	256
3500	1225	3900	1521	3100	961	3600	1296	3100	961
4200	1764	4300	1849	4300	1849	4500	2025	4300	1849
4500	2025	4600	2116	4700	2209	4900	2401	5000	2500
4300	1849	4500	2025	4700	2209	4900	2401	5000	2500
4400	1936	4600	2116	4900	2401	5100	2601	5100	2601
4200	1764	4500	2025	4800	2304	5100	2601	5300	2809
4200	1764	4500	2025	4800	2304	5000	2500	5200	2704
3800	1444	4200	1764	4500	2025	4900	2401	5100	2601
2600	676	3100	961	3800	1444	4400	1936	4900	2401
600	36	600	36	2600	676	3600	1296	4500	2025
1600	256	600	36	3500	1225	3900	1521	4300	1849
3600	1296	3900	1521	2800	784	2300	529	3100	961
3100	961	3600	1296	4100	1681	2100	441	2100	441
1100	121	1600	256	3100	961	3100	961	2800	784
600	36	1600	256	3100	961	2100	441	2100	441
Mean	798	Mean	935	Mean	1081	Mean	1154	Mean	1197
Effect	24·9	Effect	21·3	Effect	25·6	Effect	19·7	Effect	19·3

Table VII. (Continued).

Zone 37		Zone 38		Zone 39		Zone 40		Zone 41		Zone 42	
r_1	12 Miles	r_1	14 Miles	r_1	17 Miles	r_1	20 Miles	r_1	25 Miles	r_1	30 Miles
r_2	14 „	r_2	17 „	r_2	20 „	r_2	25 „	r_2	30 „	r_2	35 „
$\frac{1}{r_1}$	0·083	$\frac{1}{r_1}$	0·071	$\frac{1}{r_1}$	0·059	$\frac{1}{r_1}$	0·050	$\frac{1}{r_1}$	0·040	$\frac{1}{r_1}$	0·033
$\frac{1}{r_2}$	0·071	$\frac{1}{r_2}$	0·059	$\frac{1}{r_2}$	0·050	$\frac{1}{r_2}$	0·040	$\frac{1}{r_2}$	0·033	$\frac{1}{r_2}$	0·029
Δh	$(\Delta h)^2 \times 10^{-4}$	Δh	$(\Delta h)^2 \times 10^{-4}$	Δh	$(\Delta h)^2 \times 10^{-4}$	Δh	$(\Delta h)^2 \times 10^{-4}$	Δh	$(\Delta h)^2 \times 10^{-4}$	Δh	$(\Delta h)^2 \times 10^{-4}$
feet		*feet*		*feet*		*feet*		*feet*		*feet*	
3100	961	1600	256	1100	121	800	64	1100	121	900	81
1600	256	900	81	1100	121	800	64	1600	256	900	81
500	25	1600	256	1100	121	600	36	1100	121	1100	121
1100	121	1100	121	2100	441	2100	441	1600	256	2100	441
800	64	1600	256	3100	961	900	81	1100	121	1600	256
1100	121	1600	256	2600	676	2100	441	1600	256	1600	256
1100	121	1000	100	1600	256	2100	441	1100	121	1600	256
1300	169	1600	256	2100	441	1600	256	1600	256	1100	121
1300	169	2100	441	1600	256	2100	441	1600	256	1100	121
1600	256	3100	961	3400	1156	4100	1681	4100	1681	1100	121
3600	1296	4900	2401	5200	2704	5400	2916	5900	3481	4600	2116
4300	1849	4900	2401	5400	2916	5700	3249	5300	2809	5800	3364
5200	2704	4800	2304	4900	2401	4800	2304	5500	3025	5700	3249
5200	2704	4600	2116	4600	2116	5600	3136	5800	3364	6000	3600
5100	2601	5000	2500	4600	2116	5200	2704	5800	3364	6000	3600
5300	2809	5200	2704	4700	2209	4700	2209	5700	3249	6000	3600
5300	2809	5500	3025	5400	2916	4700	2209	5400	2916	5900	3481
5300	2809	5500	3025	5600	3136	5200	2704	5700	3249	5700	3249
5200	2704	5500	3025	5600	3136	5300	2809	4800	2304	5300	2809
5400	2916	4100	1681	4100	1681	2100	441	1600	256	4600	2116
4100	1681	1600	256	3100	961	3600	1296	1500	225	1200	144
2600	676	2100	441	1600	256	1000	100	900	81	500	25
2600	676	2100	441	1600	256	800	64	900	81	2100	441
2600	676	1600	256	1600	256	1000	100	900	81	2100	441
Mean	1299	Mean	1232	Mean	1317	Mean	1258	Mean	1330	Mean	1420
Effect	14·8	Effect	14·0	Effect	11·2	Effect	11·9	Effect	8·8	Effect	5·4

Total effect of all zones = 667·6

Attraction = 667·6 × 0·000035 = 0·0234

For the region lying outside the 35-mile radius the same assumption may be made as was suggested in the case of Basevi's station on the Camel's Back, namely, that the northern half consists of a plain at the level of the station and that the southern half is at sea level.

Attraction of infinite plain 7129 feet high	...	...	...		0·2510
Attraction of disc of 35-mile radius 7129 feet high	...	...			·2447
Difference	...	...	...	...	·0063
Half difference	...	...	...	...	·0032

Hence, for the reduction to sea level we have

$$g\frac{2h}{R} = +0\cdot668$$

$$g\frac{3}{4}\frac{h}{R} = -0\cdot251$$

Orographical correction within a radius of 35 miles	+ 0·023
" " beyond a radius of 35 miles	+ 0·003
Total ...	+ 0·443

Orographical Correction at Mussooree (Camel's Back).

Although the correction for the Camel's Back station has been so fully discussed in Volume V "*Op. G.T.S.*" yet, for the sake of the valuable test which would be afforded by a comparison of the result of an independent computation with that obtained by Basevi, I redivided the surrounding area into zones and blocks and estimated the heights afresh.

As the distance between the Camel's Back and Dunseverick is so small (under 1 mile) I only carried the process to a radius of 3 miles, and beyond that assumed that the blocks coincided with those appertaining to the zones round Dunseverick, and accepted the heights which had already been estimated. As the Camel's Back station is 200 feet lower than Dunseverick the differences in height, which enter into the computation, have of course been altered.

Tables VIII and IX contain the results arrived at; but the details of the outer zones have been given more concisely than was done in the case of Dunseverick.

Table VIII. Orographical Correction at Mussooree (Camel's Back).
Height 6924 feet.

(Computation using new estimation of heights).

No. of Zone	Inner Radius	Outer Radius	Δh	Effect	Mean Effect
	feet	*feet*			
1	150	200	24 64 94 117	1 3 6 8	4·5
2	200	250	49 87 119 154	1 3 6 8	4·5
3	250	300	62 104 139 194	2 3 5 9	4·8
4	300	350	69 114 162 209	1 3 5 8	4·3
5	350	400	82 134 184 232	2 3 5 8	4·5
6	400	500	107 167 212 254	3 7 10 13	8·3
7	500	600	159 197 242 314	4 5 8 13	7·5
8	600	700	209 237 277 367	4 6 8 13	7·8
9	700	800	217 264 331 401	4 6 8 12	7·5
10	800	900	182 309 386 431	2 6 9 11	7·0
11	900	1000	149 344 427 482	1 6 9 11	6·8
12	1000	1200	159 402 479 577	3 12 17 23	13·8
13	1200	1400	169 479 552 714	2 12 16 24	13·5
14	1400	1600	214 544 604 816	2 12 15 24	13·3
15	1600	1800	298 508 705 830	3 8 16 21	12·0
16	1800	2000	347 589 769 912	3 9 14 20	11·5
17	2000	2200	405 702 824 924	4 11 14 17	11·5
18	2200	2420	422 674 862 999	3 9 14 18	11·0
19	2420	2640 (½ mile)	412 674 962 1086	3 7 14 19	10·8
20	2640	3300 (⅝ mile)	412 812 1087 1249	6 24 41 52	30·8
21	3300	3960 (¾ mile)	349 824 1074 1424	3 16 27 46	23·0
22	3960	4620 (⅞ mile)	274 599 1174 1612	2 6 23 43	18·5
23	4620	5280 (1 mile)	262 549 1212 1724	0 4 19 37	15·0
24	5280	6600 (1¼ miles)	259 624 1324 2024	1 8 32 72	28·3
25	6600	7920 (1½ miles)	237 874 1424 2499	0 10 25 72	26·8
26	7920	9240 (1¾ miles)	324 974 1599 2674	1 9 23 60	23·3
27	9240	10560 (2 miles)	349 974 1874 2699	1 6 23 48	19·5
28	10560	13200 (2½ miles)	499 1649 2174 2999	3 25 43 82	38·3
29	13200	15840 (3 miles)	349 1624 2299 3049	1 17 33 57	27·0
30	15840	21120 (4 miles)	830 1800 2650 3580	5 25 55 98	45·8
31	21120	26400 (5 miles)	1000 1760 2830 3860	5 15 37 69	31·5

Table IX. Orographical Correction at Mussooree (Camel's Back).

Height 6924 *feet.*

(Computation using new estimation of heights).

No. of Zone	32	33	34	35	36	37	38	39	40	41	42
r_1 r_2	5 miles 6 „	6 miles 7 „	7 miles $8\frac{1}{2}$ „	$8\frac{1}{2}$ miles 10 „	10 miles 12 „	12 miles 14 „	14 miles 17 „	17 miles 20 „	20 miles 25 „	25 miles 30 „	30 miles 35 „
	Δh	Δh	Δh	Δh	Δh	Δh	Δh	Δh	Δh	Δh	Δh
	feet	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*
	600	400	2400	2400	900	1400	1400	900	600	900	700
	100	300	700	500	900	300	700	900	600	1400	900
	900	1100	500	900	1300	900	1400	900	400	900	1900
	1900	1400	1200	1200	400	600	900	1900	1900	1400	1400
	1400	1900	1600	1200	900	900	1400	2900	700	900	1400
	1100	1700	1500	1400	1200	900	1400	2400	1900	1400	1400
	600	600	600	500	500	1100	800	1400	1900	900	900
	1500	1900	100	900	1100	1100	1400	1900	1400	1400	900
	2200	2700	1400	2400	1400	1400	1900	1400	1900	1400	900
	3300	3700	2900	3400	2900	3400	2900	3200	3900	3900	4400
	4000	4100	4100	4300	4100	4100	4700	5000	5200	5700	5600
	4300	4400	4500	4700	4800	5000	4700	5200	5500	5100	5500
	4100	4300	4500	4700	4800	5000	4600	4700	4600	5300	5800
	4200	4400	4700	4900	4900	4900	4400	4400	5400	5600	5800
	4000	4300	4600	4900	5100	5100	4800	4400	5000	5600	5800
	4000	4300	4600	4800	5000	5100	5000	4500	4500	5500	5700
	3600	4000	4300	4700	4900	5100	5300	5200	4500	5200	5500
	2400	2900	3600	4200	4700	5000	5300	5400	5000	5500	5100
	400	400	2400	3400	4300	5200	5300	5400	5100	4600	4400
	1400	400	3300	3700	4100	3900	3900	3900	1900	1400	1000
	3400	3700	2600	2100	2900	2400	1400	2900	3400	1300	300
	2900	3400	3900	1900	1900	2400	1900	1400	800	700	1900
	900	1400	2900	2900	2600	2400	1900	1400	600	700	1900
	400	1400	2900	1900	1900	2900	1400	1400	800	700	700
Effect	22·0	18·9	22·9	17·6	17·4	13·3	12·6	10·1	10·8	8·0	4·9

Total effect of all zones ... ... = 651·2
Attraction ... ... = 651·2 × 0·000035 = 0·0228

It has already been shewn on p. 57 that for the irregularities beyond the 35-mile radius an allowance of 0·0028 may be made; my estimations of height therefore yield a total orographical correction of

$$0{\cdot}0228 + 0{\cdot}0028 \quad = \quad 0{\cdot}0256$$

Basevi's result was 0·0262, so that the agreement is better than could have been expected.

For the Camel's Back Station the reduction to sea level is as follows:—

$g\dfrac{2h}{R}$	=	+ 0·649
$g\dfrac{3h}{4R}$	=	− 0·243
Orographical correction within 35-mile radius		+ 0·023
" " beyond 35-mile "		+ 0·003
Total		+ 0·432

Recomputation using Basevi's heights.

The method which Col. Herschel devised for reducing the labour of the computation* was not the same as that which I have adopted and I have considered it worth while to recompute the orographical correction for Mussooree (Camel's Back), using Captain Basevi's heights and my method.

The results are given in Tables X and XI.

* *Vide* Vol. V *Op. G. T. S.* p. [164]

Table X. Orographical Correction at Mussooree (Camel's Back). Height 6924 feet.

(Recomputation using Basevi's heights).

No. of Zone	Inner Radius	Outer Radius	Δh	Effect	Mean Effect
	feet	*feet*			
1	50	100	7 16 27	0·3 1·2 3·2	1·6
2	100	150	12 32 64	0·2 1·6 5·6	2·5
3	150	200	22 49 97	0·4 1·9 6·3	2·9
4	200	250	32 65 115	0·5 2·0 5·5	2·7
5	250	300	38 90 140	0·5 2·5 5·4	2·8
6	300	350	55 117 163	0·7 3·0 5·3	3·0
7	350	400	77 147 187	1·1 3·5 5·2	3·3
8	400	500	102 187 227	2·5 7·8 10·8	7·0
9	500	600	142 233 280	3·2 7·9 11·0	7·4
10	600	700	180 275 355	3·6 7·9 12·3	7·9
11	700	800	202 323 417	3·5 8·1 12·6	8·1
12	800	900	208 362 472	3·9 8·0 12·6	8·2
13	900	1000	195 403 548	2·1 7·9 13·4	7·8
14	1000	1100	197 453 615	1·7 8·2 13·8	7·9
15	1100	1210	220 500 675	2·0 9·1 15·0	8·7
16	1210	1320	240 535 725	2·0 8·7 14·6	8·4
17	1320	1540	187 499 661 848	1·9 12·4 20·4 30·9	16·4
18	1540	1760	272 519 710 921	3·0 10·2 18·0 28·0	14·8
19	1760	1980	352 578 778 985	3·9 9·9 16·9 25·3	14·0
20	1980	2200	373 629 832 1035	3·4 9·3 15·6 22·9	12·8

No. of Zone	Inner Radius	Outer Radius	Δh	Effect	Mean Effect
	feet	*feet*			
21	2200	2420	434 689 859 1095	3·8 9·2 13·9 21·2	12·0
22	2420	2640 (0·5 mile)	465 727 926 1154	3·7 8·5 13·4 19·9	11·4
23	2640	3080 (0·583 mile)	449 812 1030 1212	5·3 16·9 26·1 35·0	20·8
24	3080	3520 (0·667 mile)	399 824 1135 1289	3·2 13·1 24·0 30·3	17·7
25	3520	3960 (0·75 mile)	368 732 1159 1393	2·1 8·2 19·8 27·7	14·5
26	3960	4620 (0·875 mile)	273 605 1110 1508	1·3 6·5 21·1 37·5	16·6
27	4620	5280 (1 mile)	202 510 1070 1562	0·5 3·5 14·9 30·7	12·4
28	5280	6600 (1·25 ml.)	334 703 1170 1876	2·1 9·3 25·2 62·0	24·7
29	6600	7920 (1·50 ml.)	274 872 1565 2353	1·0 9·5 29·9 64·8	26·3
30	7920	9240 (1·75 ml.)	320 1270 1842 2692	1·0 14·3 29·6 60·8	26·4
31	9240	10560 (2 miles)	592 1531 2242 2998	2·3 11·9 32·7 56·9	26·0
32	10560	13485 (2·554 ml.)	787 1720 2487 3198	6·1 29·8 61·5 99·5	49·2
33	13485	17218 (3·261 ml.)	709 1898 2709 3375	4·0 28·6 57·6 88·2	44·6
34	17218	21991 (4·165 ml.)	831 2131 2775 3476	4·3 28·3 47·8 74·4	38·7
35	21991	28079 (5·318 ml.)	1220 2287 3020 3809	7·3 25·6 44·5 70·2	36·9

Effect of zones up to a radius of 5·318 miles = 526·4

Attraction = 526·4 × 0·000035 = 0·0184

Table XI. Orographical Correction at Mussooree (Camel's Back).

(Recomputation using Baseui's heights.)

No. of Zone	36	37	38	39	40	41	42	43
r_1 r_2	5·318 ml. 6·791 „	6·791 ml. 8·672 „	8·672 ml. 10·075 „	10·075 ml. 14·142 „	14·142 ml. 18·059 „	18·059 ml. 23·061 „	23·061 ml. 29·449 „	29·449 ml. 37·606 „
	Δh	Δh	Δh	Δh	Δh	Δh	Δh	Δh
	feet	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*
	1920	2420	2420	2920	3220	2920	1920	920
	1420	1920	1920	1920	1920	2420	2420	920
	1920	420	420	920	1420	1420	920	920
	1720	1420	1080	920	1920	1420	920	80
	1920	2220	420	920	2420	2920	2420	1080
	2220	2220	1420	1920	2920	2920	1920	920
	2520	2220	1620	1420	3420	2420	920	1080
	2220	2420	1820	1420	3420	2920	3420	920
	1220	1420	1920	1420	2920	3920	3420	2920
	220	80	1420	1420	920	3420	2420	2920
	220	220	80	80	1420	2920	3920	2920
	1420	1920	1920	2920	2920	1920	3920	3920
	1920	2920	2920	3420	3420	3420	1920	3920
	2920	3420	3420	3920	3920	2920	3920	4420
	3620	3720	3920	4220	4420	4420	4920	4920
	3920	3920	4420	4220	4920	5420	5820	5420
	4020	4420	4620	4920	5220	5420	5620	5620
	3920	4520	4720	5020	5020	5220	5220	5620
	4020	4420	4620	4920	4920	4820	5420	5820
	4020	4420	4620	4920	4620	4720	5820	6020
	4020	4420	4620	4920	4520	4920	5920	6020
	4020	4420	4820	5020	4620	4620	5920	6020
	3820	4420	4920	5120	4920	4420	5920	6020
	3620	4220	4920	5120	5120	4420	5720	6020
	3220	4420	4720	5020	5120	4920	5420	6020
	2720	3920	4620	5020	5120	5020	5220	5720
	2220	3620	4420	4920	5120	5320	5420	5220
	1120	3420	3920	4920	5220	5220	5220	5220
	1820	2920	3420	4920	4420	3920	4420	3520
	3220	3420	3920	4420	4420	4420	3420	1620
	3920	3420	3420	2920	2920	4220	2920	920
	3420	3720	2920	1920	3420	3420	3420	1920
	2920	3720	3420	2920	1920	920	2920	1920
	2620	3420	3920	3420	2420	920	1920	1920
	2420	2920	3420	3920	2420	1420	420	920
	1920	2620	2920	3420	2920	2420	920	920
Effect	31·2	32·9	19·6	36·9	22·3	16·6	14·2	10·5

Effect of zones from 5·318 miles to 37·606 miles = 184·2

Attraction = 184·2 × 0·000035 = 0·0064

The method of grouping blocks in order of height has been used up to a radius of 5·318 miles; beyond this, formula (2) has been employed, and the height of each block separately taken into account.

Up to 5·318 miles the calculation in *Vol. V. Op. G. T. S.* gives as the correction to the vibration number

8·6010,

which is equivalent to a correction of $\overset{cm}{0 \cdot 1956}$ to the value of g.

The attraction of a disc of this radius and 6920 feet high is 0·2129; my computation of the defect due to inequalities yields 0·0184 and hence the attraction of the actual masses within a radius of 5·318 miles is

$$0 \cdot 2129 - 0 \cdot 0184 = 0 \cdot 1945$$

As has already been explained, the effect of all levelling processes implied in the employment of mean heights, is to increase the attraction of the masses, the fact therefore that the new result is slightly less than the old one is favourable to the new method.

Between the radii of 5·318 and 37·606 miles the new computation gives as the defect due to inequalities

0·0064

The attraction of a zone bounded by cylinders of the above radii and 6920 feet high is, by formula (2),

0·0256

Hence the attraction of the actual masses is

$$0 \cdot 0256 - 0 \cdot 0064 = 0 \cdot 0192$$

Col. Herschel's computation for the same zone gives in terms of N

0·8450

and this when converted into terms of the acceleration in centimeters is also

0·0192

Madras and Colaba.

No orographical corrections have been applied at Madras and Colaba. It might be thought that some allowance should be made for the presence of the sea; but, as has been remarked already, the present object is to reduce to sea level, so as to obtain numbers which may be compared with the computed values of γ_0, and just as a uniform density has been assigned to all masses lying above sea level, so we must for the present refrain from differentiating between the substances which lie below it.

Orographical Correction at Dehra Dun.

In *Volume V. Op. G. T. S.* p. [177] the effect of the inequalities of the surface on the pendulum station at Dehra Dún is computed. The effect on the vibration number, of the zones up to a radius of 30 miles, is found to be

3·305

Which corresponds to a difference of

0·0752 in g.

The attraction of a disc 2240 feet high and 30 miles in radius is

0·0780

So that the orographical correction within a radius of 30 miles is

0·0028

The total effect of all the zones up to an indefinitely great distance is found to be

3·18

This corresponds to ... ... 0·0724

The attraction of an infinite disc 2240 feet thick is

0·079

The difference is ... ... 0·0066

Thus the attraction of the zones outside a radius of 30 miles is

$$0 \cdot 0066 - 0 \cdot 0028 = 0 \cdot 0038$$

It appears that all the particulars of Basevi's estimation of the heights of the compartments were not recoverable and as a check I have estimated the masses outside the 30-mile radius anew, as follows:—

Azimuth (from south by west)			Mean height
0° to 120°	...	...	... 900 feet
120 „ 180	...	...	... 5000 „
180 „ 250	...	...	... 9000 „
250 „ 270	...	...	... 5000 „
270 „ 315	...	...	... 4000 „
315 „ 360	...	...	... 900 „

The orographical correction due to the difference between these masses and the infinite plain through the station outside the 30-mile radius is

$$0{\cdot}0013$$

So that the total orographical correction becomes

$$0{\cdot}0028 + 0{\cdot}0013 = 0{\cdot}0041$$

which is in good agreement with Basevi's result.

In Table XII the observed values of g, the reductions to sea level, the theoretical values of γ_0 and the differences are exhibited.

Table XII. Synopsis of Results.

Station	Latitude	Height	Observed g	$g\frac{2h}{R}$	$g\frac{3}{4}\frac{h}{R}$	O	Value at sea level g_0''	γ_0	$g_0'' - \gamma_0$
	° ′	feet							
Dehra Dún	30 19	2239	979·063	+0·210	−0·079	+0·004	979·198	979·324	−0·126
Madras	13 4	20	978·279	+0·002	−0·001	0	978·280	978·266	+0·014
Colaba	18 54	34	978·631	+0·003	−0·001	0	978·633	978·545	+0·088
Mussooree (Dunseverick)	30 27	7129	978·776	+0·668	−0·251	+0·026	979·219	979·334	−0·115
Mussooree (Camel's Back)	30 28	6924	978·793	+0·649	−0·243	+0·026	979·225	979·335	−0·110

CHAPTER III.

The Operations in the year 1904-05.

The locale of operations during this field season lay along the chain of triangles known as the Calcutta Meridional Series.

This line was selected by Colonel Burrard, Superintendent of Trigonometrical Surveys, for several reasons. It crosses the subterranean chain of excessive density, the existence of which was pointed out by him in professional paper No. 5: latitude observations recently made at stations of this series had shewn that the local deflection of the plumb-line must be largely influenced by invisible causes: the series runs right up to the foot of the Himalayas and meets them at a point whence the roads to Darjeeling and along the Nepal frontier afford unusual facilities for reaching points of considerable altitude: and, lastly, this part of the country was comparatively free from plague which was very bad in the United Provinces and in the Punjab.

As no houses were to be found in the neighbourhood of several of the stations which were selected, some portable arrangement had to be considered. It was thought that a tent of good quality would probably answer, and a large single poled tent, divided into two rooms by a curtain, was accordingly purchased. Inside one of the rooms an inner roof, consisting of ruberoid laid on a bamboo frame-work, was provided. An inspection of the results will shew that the protection from the sun's radiation was not sufficient, and that the temperature was far from steady.

During the summer of 1904 a new pendulum room had been prepared at Dehra Dún in the building which contains the great Photoheliograph. The new room was much superior to that in which the observations of January and June 1904 had been made, particularly as regards the temperature conditions.

The new station is due east of the old one and 590 feet distant from it. The floor of the new room is 2ft. higher than that of the old one.

Sets of observations were made in the new room and in the tent, or field station, both before proceeding to the field and after returning from it.

A difficult question has been how to deal with the observations taken in an unsteady temperature.

In Dehra Dún the mean hourly variations in the tent for each day and night were in degrees centigrade:—

	Night	Day
in November	− ·05	+ 1·03
	− ·14	+ 0·60
and in May	− ·21	+ ·45
	− ·27	+ ·76
	− ·19	+ ·57

In the case of observations made in a room where the temperature varies but little, and that slowly, so long as the room is kept closed, and only commences to change when the observations begin, on account of the opening of the door, and of the presence of the observer and the necessary lamps, a correction of the form $K \frac{d\theta}{dt}$ is probably capable of expressing the difference between the temperature of the pendulum and that indicated by the thermometers. But when the principal cause of the change of temperature is the sun and the weather, it does not seem probable that such an expression, which only takes into account variations in the temperature over a short period, will be adequate. The difference of temperature must be a function not only of the rate of increase of temperature but also of the time that has elapsed since the rise began, and of the conditions preceding the rise. It seems impossible in the absence of data respecting those conditions to arrive at any satisfactory estimate of the difference in question, and I have thought it best, in the case of the tent stations, to apply no correction for lag, and to determine *g* by comparing the observed time of vibration with that obtained in the tent at Dehra Dún, trusting to the similarity of the conditions to eliminate the errors due to wrongly estimated temperatures.

At several of the stations houses more or less suitable were available and at two of those where there were no houses, huts of bamboo mats plastered with mud were made. In the latter and in the less suitable of the former the conditions did not correspond exactly either to those of the tent or of the room at Dehra Dún, and *g* has been deduced firstly by comparing the observed time of vibration with that obtained at the Dehra Dún field station applying no lag correction, and, secondly, by comparing with that obtained in the pendulum room applying a lag correction; finally the mean of the two results has been taken.

In this way the magnitude of the uncertainty in the deduced *g*, to which the unsteady temperature gives rise, is exhibited.

At stations where houses not greatly inferior to the pendulum room were available, comparison has only been made with the observations made in the latter, the lag correction being applied as usual.

Throughout this season the time observations were made by Extra Assistant Superintendent Hanuman Prasad with Transit Instrument No. 2 by Troughton & Simms. The half-seconds pendulum clock S.R. 238 was used to actuate both the chronograph and the flash-box. The chronograph was the same one as had been used in the former season, namely the heavy drum chronograph made by Messrs. Warner and Swasey.

The pendulum stand was always erected on a brick pillar specially built for it, and at the stations where the tent was used small blocks of bricks in cement were made for the feet of the clock stand.

The same thermometers were used as during the former season, *viz*: Nos. 105368 and 105369 by Negretti and Zambra.

The pressure of the air was measured by a mercurial barometer on Fortin's principle; an aneroid barometer was also carried and read, chiefly as a safeguard against accidental gross errors in reading the mercurial one.

The humidity was determined by readings of wet and dry bulb thermometers.

At the end of January Professor Dr. O. Hecker of the Prussian Geodetic Institute joined me while I was at Jalpaiguri. Dr. Hecker had been engaged upon an important series of observations with barometers and hypsometers, made during voyages to Australia, Japan and elsewhere, for determining the force of gravity in mid-ocean, but he was also equipped with a set of pendulums and the necessary accessories, and the excellent suggestion was made by Professor Helmert that he should visit India on his way home from Japan, join the pendulum party wherever it might be, and swing his pendulums alongside of ours.

I selected Jalpaiguri as the most convenient place for the simultaneous observations, and was so fortunate as to secure as an observatory a good room in which the temperature was satisfactorily steady.

By means of these observations an independent value of g at Dehra Dún is obtained. For my work gives the difference Dehra Dún—Jalpaiguri and Dr. Hecker's gives Potsdam—Jalpaiguri, whence Potsdam—Dehra Dún becomes known. The absolute value of g at Potsdam, which has recently been determined with extreme care, is 981·274. The value which has been adopted for Kew, namely 981·200 is based on the Potsdam determination, and rests on the measure of the difference made by Mr. G. R. Putnam in 1900. We have an indirect check on Mr. Putnam's result through the chain Kew—Dehra Dún—Jalpaiguri—Potsdam. The details of Dr. Hecker's observations are given at the end of this Chapter.

THE STATIONS.

Dehra Dun.

The new pendulum room is situated in the observatory which contains the large photoheliograph.

The new pendulum pillar is due east of Basevi's station, 590 feet from it and 2 feet higher.

The co-ordinates of new pendulum station are:—

	°	′	″
Latitude	30	19	29
Longitude	78	3	22
Height above mean sea level ...		2241 feet	

The Dehra Dún field station is 62 feet north and 5 feet east of the pillar in the pendulum room, and the ground on which it stands is 1 foot lower than the floor of the room.

In November 1904, before starting for the field, observations were taken both in the room and at the field station.

In the room the flexure correction was determined five times.

8th November	13th November
$46^s\cdot7 \times 10^{-7}$	$41^s\cdot5 \times 10^{-7}$
42·4	45·8
	44·6

Adopted Correction $-44^s \times 10^{-7}$

At the field station it was determined four times.

21st November	24th November
$41^s\cdot3 \times 10^{-7}$	$40^s\cdot7 \times 10^{-7}$
41·2	41·7 .

Adopted Correction $-41^s \times 10^{-7}$

Cuttack G. T. S.

No. XXXV of the East Coast Series.

The pendulum station was in a small house, which had originally been erected as a cholera hospital but had never been used. The pillar was about 480 feet north and 23 feet west of the Cuttack G. T. S.

The co-ordinates of the pendulum pillar are :—

		°	′	″
Latitude	... ...	20	29	5
Longitude	... ...	85	52	1
Height	... ...	92 feet		

The temperature conditions were not good, chiefly owing to there being a space between the walls and the roof for ventilation. The results have been taken out both with and without a lag correction, for comparison with the two Dehra Dún values.

The flexure correction was determined six times.

December 12th	December 16th	December 17th
$61^{s}\cdot4 \times 10^{-7}$	$52^{s}\cdot4 \times 10^{-7}$	$51^{s}\cdot4 \times 10^{-7}$
60·7	51·4	52·5

There is large change between the results of the 12th and 16th due undoubtedly to the gradual hardening of the cement in the pillar, which at this station it had not been possible to build beforehand. For the observations between the 12th and 16th a flexure correction of $-56^{s} \times 10^{-7}$ has been adopted, and for those on the 16th and 17th one of $-52^{s} \times 10^{-7}$.

Chatra G. T. S.

No. XVIII of the Calcutta Meridional Series.

The station of the principal triangulation has been completely washed away by the Bhairab river. But its position was fairly well known to the villagers and I do not think there can be an error of more than 50 yards in the point which they showed me. The pendulum pillar was 300 yards south and 550 yards west of the most probable position of the old Tower station. The country is perfectly flat for miles in every direction and it has been assumed that the ground level at the new station is the same as it was at the old one.

The co-ordinates of the pendulum station are :—

		°	′	″
Latitude	... ...	24	12	40
Longitude	... ...	88	23	27
Height above mean sea level	...	64 feet		

The tent formed the observatory.

The flexure correction was determined five times as follows :—

December 30th	January 1st	January 3rd
$63^{s}\cdot1 \times 10^{-7}$	$58^{s}\cdot7 \times 10^{-7}$	$59^{s}\cdot9 \times 10^{-7}$
63·6		57·4

The following values have been adopted :—

December 30 / „ 31	$-61^{s} \times 10^{-7}$
December 31 / January 1	-61×10^{-7}
January 1 / „ 2	-59×10^{-7}

Kisnapur G. T. S.

No. XXIX of the Calcutta Meridional Series.

The pendulum pillar was situated 851 feet south and 83 feet east of the G. T. station and on ground 4 feet lower than that surrounding the base of the old Tower. The latter was not entire and the upper mark-stone could not be found, so there is a little uncertainty as to the height, for the ground is uneven, but there cannot be an error of more than 3 feet.

The co-ordinates of the pendulum station are:—

		°	′	″
Latitude	... ...	25	2	26
Longitude	... ...	88	28	29
Height above mean sea level	...	113 feet		

The tent formed the observatory.

The flexure correction was determined seven times:—

January 17	January 19	January 21	January 23
s	s	s	s
$64 \cdot 6 \times 10^{-7}$	$57 \cdot 4 \times 10^{-7}$	$56 \cdot 5 \times 10^{-7}$	$56 \cdot 7 \times 10^{-7}$
65·4	55·9	54·4	

The following values of the correction have been adopted:—

		s
January	17–18	-61×10^{-7}
„	18–19	−61 „
„	19–20	−57 „
„	21–22	−56 „
„	22–23	−57 „

There was a good deal of cloud and rain at this station and star observations were only obtained on the 17th, 20th, 21st and 23rd. The five sets of observations therefore only yield two independent results, namely, (1) those from the evening of 17th to the morning of the 20th, and (2) those from the evening of the 21st to the morning of the 23rd.

Jalpaiguri.

The pendulum station was situated in a room of a building belonging to the District Treasury. The pillar was 123 feet west and 63 feet north of the station of the triangulation called Jalpaiguri s. The latter is on the roof of another of the Treasury buildings.

The co-ordinates of the pendulum station are:—

		°	′	″
Latitude	...	26	31	16
Longitude	...	88	44	13
Height above mean sea level		268 feet		

One of the lines of principal levelling runs up the railway which passes through Jalpaiguri, and there is a bench-mark at the station. A subsidiary line of levels was run from this bench-mark to the pendulum room.

The floor was of thick concrete and isolated pillars were not provided.

Dr. Hecker's apparatus and mine were set up at opposite ends of the room, the clock being between them. The same clock, namely S.R. 238, was used for timing both sets of pendulums.

The pillars for both instruments had to be erected hurriedly after the arrival of the observers, and in consequence the cement was not hard when work began. The result of this is clearly seen in the flexure correction.

I determined this correction eight times with the following results:—

January 31st 6 P.M.	February 1st 6 P.M.	February 2nd 4 P.M.	February 3rd 6 P.M.
$54^{s}\cdot2 \times 10^{-7}$ $52\cdot1$	$43^{s}\cdot6 \times 10^{-7}$ $44\cdot6$	$44^{s}\cdot1 \times 10^{-7}$ $44\cdot5$	$42^{s}\cdot8 \times 10^{-7}$ $40\cdot3$
$53\cdot2 \times 10^{-7}$	$44\cdot1 \times 10^{-7}$	$44\cdot3 \times 10^{-7}$	$41\cdot6 \times 10^{-7}$

By plotting these values as the ordinates of points, of which the abscissæ were intervals of time, and drawing a smooth curve through them the following values of the flexure correction were obtained:—

January	31	Night	$-50^{s} \times 10^{-7}$	
February	1	Day	-46	„
„	1	Night	-44	„
„	2	Day	-44	„
„	2	Night	-43	„
„	3	Day	-42	„

The temperature conditions were good and g has been determined by comparison with the observations in the pendulum room at Dehra Dún, applying the usual lag correction.

Kesarbari G. T. S.

No. XLIII of the Calcutta Meridional Series.

The pendulum pillar was situated 194 feet east and 24 feet south of the G. T. S. and on ground 5 feet lower than that at the base of the Tower. The upper mark-stone of the latter was missing and there is therefore an uncertainty of about 2 feet in the height.

The co-ordinates of the pendulum station are:—

		°	′	″
Latitude	... ...	26	7	41
Longitude	... ...	88	31	26
Height above mean sea level	...	204 feet		

The tent formed the observatory, but as an additional protection against variations of temperature a hut of thatch and matting was erected inside the tent.

Bad weather was encountered here; star observations were only obtained on February 14th and 18th. The sky was overcast from 11 p. m. on the 14th until 10 a. m. on the 18th. The four sets of observations only yield one value of the time of vibration.

The flexure correction was determined six times:—

	February 14th	February 15th	February 18th
	$73^{s}\cdot4 \times 10^{-7}$	$69^{s}\cdot4 \times 10^{-7}$	$68^{s}\cdot4 \times 10^{-7}$
	$71\cdot2$	$72\cdot9$	$69\cdot8$
Adopted correction		$-71^{s} \times 10^{-7}$	

Ramchandpur.

The pendulum station was situated 3390 feet north and 2355 feet east of Rámchandpur G. T. S. No. XXXVII of the Calcutta Meridional Series, and on ground 14 feet higher than that at the base of the Tower.

The co-ordinates of the pendulum station are:—

	°	′	″
Latitude	25	40	57
Longitude	88	32	58
Height above mean sea level ...		132 feet	

At this station the tent was not used but a room was constructed of bamboos, thatch and mud plaster under a large mango tree. It was to obtain the advantage of the shadé of this tree that a point so distant from the Tower was selected.

The flexure correction was determined seven times:—

25th February	26th February	28th February
s	s	s
$66 \cdot 0 \times 10^{-7}$	$69 \cdot 4 \times 10^{-7}$	$64 \cdot 3 \times 10^{-7}$
69·6		63·2
71·2		
67·6		

Adopted values of the correction

	s
25—26th February	-69×10^{-7}
26—27	−68
27—28	−66

Siliguri.

A bungalow belonging to the Jalpaiguri District Board was lent me for the pendulum observations. It is situated about 1½ miles W. S. W. of the Siliguri railway station. There is a bench-mark of the principal levelling on the step of the bungalow and a secondary triangulation station about 200 yards further south, at the side of the main road to Titalia.

The co-ordinates of the pendulum station are:—

	°	′	″
Latitude	26	41	47
Longitude	88	24	50
Height above mean sea level ...		387 feet	

The floors of the two main rooms of the bungalow were of wood, but that of the bath-room of the larger of the two was of concrete. I therefore built the pendulum pillar in the bath-room and observed through the door. The clock also was erected in the bath-room.

The roof of this room was of iron and I had a layer of earth laid upon it, even so however the temperature conditions were not good and *g* has been determined by both of the methods described on p. 71.

The observations were greatly delayed by bad weather. I arrived on the 8th March but could get no star observations till the 12th; the 14th and 15th were also cloudy and the closing observations were not obtained until the 16th.

Flexure was observed several times before work began, but the observations which have been utilised in deducing the correction were only 4 in number, *viz.*,

13th February	16th February
$64{\cdot}4^{s} \times 10^{-7}$	$63{\cdot}4^{s} \times 10^{-7}$
$64{\cdot}9$	$64{\cdot}5$

Adopted Correction $-64^{s} \times 10^{-7}$

Darjeeling.

The pendulum pillar was erected in a room with a northerly aspect on the ground floor of the Bengal Secretariat office.

The floor of the room was found by vertical angles and levelling to be 202 feet below the station of the triangulation on Observatory Hill, and the pendulum pillar was approximately 400 feet south and 500 feet west of that station.

The co-ordinates of the pendulum pillar are therefore :—

	°	′	″
Latitude	27	2	47
Longitude	88	16	8
Height above mean sea level ...	6966 feet		

The room was a very suitable one, the temperature conditions were satisfactory and the clock and pendulum pillars free from liability to tremors.

The flexure correction was determined five times.

20th March	23rd March
$57{\cdot}4^{s} \times 10^{-7}$	$56{\cdot}0^{s} \times 10^{-7}$
$58{\cdot}2$	$54{\cdot}5$
$60{\cdot}7$	

Adopted Correction $-57^{s} \times 10^{-7}$

Kurseong.

The pendulum pillar was built in the bath-room of the north room of the Dâk or Inspection bungalow. This bungalow is situated close to the railway on its eastern side and about a quarter of a mile above the railway station.

The level of the floor was determined by spirit-levelling from the railway station. A traverse was run to a station of the secondary triangulation in order to obtain the latitude and longitude.

The co-ordinates of the pendulum station are :—

	°	′	″
Latitude	26	52	51
Longitude	88	16	45
Height above mean sea level ...	4913 feet		

The floor of the bath-room was of cement and of good quality but that of the room was of planks and very unsteady. The clock was fixed to the wall of the room.

Flexure was observed seven times.

26th March	27th March	30th March	1st April
$35^s.7 \times 10^{-7}$	$35^s.3 \times 10^{-7}$	$34^s.7 \times 10^{-7}$	$35^s.8 \times 10^{-7}$
35·4	...	34·0	35·3

Adopted Correction $- 35^s \times 10^{-7}$

Sandakphu.

The hill of this name is a peak of a remarkable spur which extends from Kinchinjunga to the plains. The Nepal frontier runs along this ridge and a road has been constructed almost parallel to the frontier on the British side of it. There are rest-houses at intervals along this road and that at Sandakphu was kindly placed at my disposal by the Deputy Commissioner of Darjeeling.

The floors of the rest-house are planked but I was able to erect the pendulum pillar in the bath-room in the same way as I had done at Siliguri and Kurseong. The clock was fixed to the wall of the room.

There is a station of the triangulation on the peak of Sandakphu and the pendulum pillar was 560 feet north and 1150 feet east of it.

The elevation of the floor of the room was 163 feet less than that of the triangulation station.

The co-ordinates of the pendulum station are:—

		°	′	″
Latitude	... ...	27	6	6
Longitude	... ...	88	0	15
Height above mean sea level	...	11766 feet		

The observations at this station were carried out under somewhat adverse circumstances. The spring had been an unusually severe one and the snow-fall had been heavy, so that the road was only just open at the time when the party started from Kurseong, although the date of starting had been put as late as possible. The march was accomplished without serious difficulty, but after the instruments had been erected and during the progress of the observations very bad weather was met with. No star observations were obtained on the 9th of April which was the first night: on the 10th there were clouds till 10 p.m. then however it cleared for two hours; a good time determination was made, and I was enabled to begin observing the pendulums. The next evening it was clear from 7 p.m. till about 10 p.m. and good observations were obtained. On the 12th there was a severe snowstorm with high wind in the afternoon and the sky remained cloudy all night though hope of success was not abandoned till 2 a.m. On the 13th there was a heavy fall of snow in the afternoon followed by a perfect hurricane of wind which blew all night: the sky however was clear from about 8 p.m. and Babu Hanuman Prasad succeeded in getting a sufficient number of stars, though in the face of great difficulties, for the wind was sending the powdery snow whirling through the meridional slit, and there seemed to be imminent danger of the whole tent being blown away; it was moreover intensely cold. The advantage of having a large and stable transit-instrument and a good drum chronograph was clearly shewn, for no trustworthy observations by the eye and ear method, or with a light instrument, would have been possible on any of the nights of our stay.

The room in the rest-house was good and it was possible to keep the temperature fairly steady.

The flexure correction was determined six times.

	10th April	12th April	13th April
	$47^{s}\cdot 7 \times 10^{-7}$	...	$46^{s}\cdot 3 \times 10^{-7}$
	$50\cdot 5$	$45^{s}\cdot 6 \times 10^{-7}$	$47\cdot 0$
	$47\cdot 4$	...	...
Mean	$48\cdot 5$	$45\cdot 6$	$46\cdot 7$

Adopted Correction $-47^{s} \times 10^{-7}$

Dehra Dun.

On returning to Dehra Dún observations were again made both at the field station and in the pendulum room.

At the field station flexure was observed six times.

9th May	10th May	16th May
$35^{s}\cdot 4 \times 10^{-7}$		$36^{s}\cdot 2 \times 10^{-7}$
$39\cdot 5$	$36^{s}\cdot 1 \times 10^{-7}$	$36\cdot 8$
$37\cdot 5$		

Adopted Correction $-37^{s} \times 10^{-7}$

In the room it was observed four times.

17th May	21st May
$41^{s}\cdot 5 \times 10^{-7}$	$42^{s}\cdot 7 \times 10^{-7}$
$40\cdot 2$	$42\cdot 5$

Adopted Correction $-42^{s} \times 10^{-7}$

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
	Dehra Dun—(*Pendulum room*).														
	8-9 November, 1904.														
	h m	s	s	′	°	°		s							s
137	2 26	34·238	− 0·31	13	20·34	+0·09	0·850	0·5074100	+ 18	−5	− 997	+ 2	− 505	−44	0·5072569
139	3 25	34·681	0·31	12	20·56	0·09	0·849	0·5073141	18	4	1007	2	514	44	0·5071592
138	4 29	33·182	0·31	13	20·61	0·09	0·850	0·5076495	18	5	1010	2	486	44	0·5074970
140	5 26	35·040	0·31	15	20·65	0·09	0·850	0·5072380	18	6	1012	2	515	44	0·5070823
													Mean	...	0·5072489
137	14 39	34·218	− 0·31	13	20·28	+0·11	0·851	0·5074145	+ 18	−5	− 994	+ 3	− 505	−44	0·5072618
139	15 37	34·659	0·31	12	20·40	0·11	0·850	0·5073187	18	4	1000	3	515	44	0·5071645
138	16 42	33·156	0·31	14	20·52	0·11	0·849	0·5076556	18	5	1005	3	486	44	0·5075037
140	17 37	35·034	0·31	13	20·58	0·11	0·849	0·5072395	18	5	1008	3	514	44	0·5070845
													Mean	...	0·5072536
								Time of Vibration of Mean Pendulum						...	**0·5072513**
	9-10 November, 1904.														
140	2 32	35·042	− 0·45	13	20·52	−0·04	0·852	0·5072376	+ 26	−5	−1005	− 1	− 516	−44	0·5070831
138	3 35	33·169	0·45	13	20·59	0·04	0·853	0·5076525	26	5	1009	1	488	44	0·5075004
139	4 32	34·676	0·45	14	20·48	0·04	0·853	0·5073151	26	5	1004	1	517	44	0·5071606
137	5 30	34·229	0·45	13	20·49	0·04	0·853	0·5074120	26	5	1004	1	507	44	0·5072585
													Mean	...	0·5072506
140	14 50	35·030	− 0·45	14	20·18	+0·13	0·853	0·5072400	+ 26	−5	− 989	+ 3	− 517	−44	0·5070874
138	15 48	33·159	0·45	14	20·34	0·13	0·853	0·5076549	26	5	997	3	488	44	0·5075044
139	16 45	34·658	0·45	13	20·45	0·13	0·851	0·5073188	26	5	1002	3	516	44	0·5071650
137	17 44	34·208	0·45	15	20·55	0·13	0·849	0·5074167	26	6	1007	3	504	44	0·5072635
													Mean	...	0·5072551
								Time of Vibration of Mean Pendulum						...	**0·5072529**
	10-11 November, 1904.														
139	2 47	34·679	− 0·61	14	20·56	−0·01	0·850	0·5073145	+ 36	−5	−1007	0	− 515	−44	0·5071610
137	3 44	34·239	0·61	14	20·57	0·01	0·852	0·5074098	36	5	1008	0	506	44	0·5072571
140	4 44	35·043	0·61	13	20·54	0·01	0·851	0·5072372	36	5	1006	0	516	44	0·5070837
138	5 43	33·174	0·61	14	20·58	0·01	0·850	0·5076515	36	5	1008	0	486	44	0·5075008
													Mean	...	0·5072507
139	14 52	34·679	− 0·61	13	20·29	+0·12	0·851	0·5073145	+ 36	−5	− 994	+ 3	− 516	−44	0·5071625
137	15 49	34·227	0·61	15	20·46	0·12	0·850	0·5074126	36	6	1003	3	505	44	0·5072607
140	16 48	35·033	0·61	14	20·55	0·12	0·849	0·5072396	36	5	1007	3	514	44	0·5070865
138	17 44	33·163	0·61	14	20·64	0·12	0·848	0·5076538	36	5	1011	3	485	44	0·5075032
													Mean	...	0·5072532
								Time of Vibration of Mean Pendulum						...	**0·5072519**
	11-12 November, 1904.														
138	3 12	33·168	− 0·67	14	20·55	+0·06	0·851	0·5076529	+ 39	−5	−1007	+ 2	− 487	−44	0·5075027
140	4 8	35·029	0·67	14	20·51	0·06	0·851	0·5072402	39	5	1005	2	516	44	0·5070873
137	5 8	34·220	0·67	14	20·61	0·06	0·850	0·5074140	39	5	1010	2	505	44	0·5072617
139	6 3	34·665	0·67	14	20·67	0·06	0·850	0·5073175	39	5	1013	2	515	44	0·5071639
													Mean	...	0·5072539
138	15 15	33·179	− 0·67	14	20·33	+0·02	0·855	0·5076501	+ 39	−5	− 996	+ 1	− 489	−44	0·5075007
140	16 12	35·047	0·67	14	20·40	0·02	0·854	0·5072366	39	5	1000	1	518	44	0·5070839
137	17 13	34·237	0·67	14	20·40	0·02	0·854	0·5074103	39	5	1000	1	507	44	0·5072587
139	18 12	34·680	0·67	14	20·40	0·02	0·851	0·5073142	39	5	1000	1	516	44	0·5071617
													Mean	...	0·5072513
								Time of Vibration of Mean Pendulum						...	**0·5072526**
								General Mean						...	**0·5072522**

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
Dehra Dun—*(Field Station, Tent).*															
21-22 November, 1904.															
	h m	s	s	′	°	°		s							s
137	6 23	34·349	− 1·11	15	15·46	−0·05	0·873	0·5073858	+ 65	−6	− 758	No lag correction applied	− 519	−41	0·5072599
139	7 26	34·797	1·11	16	15·54	0·05	0·872	0·5072892	65	7	761		528	41	0·5071620
138	8 27	33·284	1·11	17	15·47	0·05	0·873	0·5076256	65	8	758		499	41	0·5075015
140	9 26	35·165	1·11	15	15·32	0·05	0·874	0·5072118	65	6	751		530	41	0·5070855
													Mean	...	0·5072522
137	18 32	34·370	− 1·11	15	15·75	+1·03	0·861	0·5073812	+ 65	−6	− 772		− 511	−41	0·5072547
139	19 29	34·797	1·11	16	16·85	1·03	0·856	0·5072893	65	7	826		519	41	0·5071565
138	20 27	33·264	1·11	16	17·84	1·03	0·852	0·5076302	65	7	874		487	41	0·5074958
140	21 26	35·111	1·11	16	18·67	1·03	0·849	0·5072230	65	7	915		514	41	0·5070818
													Mean	...	0·5072472
								Time of Vibration of Mean Pendulum						...	**0·5072497**
22-23 November, 1904.															
140	6 14	35·158	− 1·18	16	15·77	−0·14	0·872	0·5072132	+ 69	−7	− 773	No lag correction applied	− 528	−41	0·5070852
138	7 13	33·282	1·18	14	15·73	0·14	0·872	0·5076261	69	5	771		499	41	0·5075014
139	8 14	34·796	1·18	14	15·58	0·14	0·872	0·5072896	69	5	763		528	41	0·5071628
137	9 15	34·351	1·18	14	15·36	0·14	0·872	0·5073855	69	5	753		518	41	0·5072607
													Mean	...	0·5072525
140	18 29	35·190	− 1·18	16	15·24	+0·60	0·863	0·5072067	+ 69	−7	− 747		− 523	−41	0·5070818
138	19 27	33·293	1·18	15	16·09	0·60	0·859	0·5076235	69	6	788		491	41	0·5074978
139	20 27	34·789	1·18	15	16·63	0·60	0·857	0·5072912	69	6	815		519	41	0·5071600
137	21 24	34·326	1·18	15	17·08	0·60	0·856	0·5073908	69	6	837		508	41	0·5072585
													Mean	...	0·5072495
								Time of Vibration of Mean Pendulum						...	**0·5072510**
													General Mean	...	**0·5072504**
Cuttack.															
12-13 December, 1904.															
	h m	s	s	′	°	°		s							s
137	3 27	33·314	+13·40	16	23·10	−0·42	0·914	0·5076187	−787	−7	−1132	− 11	− 543	−56	0·5073651
139	4 23	33·745	13·40	16	22·80	0·42	0·917	0·5075200	787	7	1117	11	556	56	0·5072666
138	5 21	32·326	13·40	17	22·32	0·42	0·921	0·5078553	787	7	1094	11	527	56	0·5076071
140	6 15	34·102	13·40	17	21·95	0·42	0·921	0·5074401	787	8	1076	11	558	56	0·5071905
													Mean	...	0·5073573
137	15 33	33·360	+13·40	17	22·12	+0·76	0·914	0·5076080	−787	−8	−1084	+ 19	− 543	−56	0·5073621
139	16 32	33·769	13·40	16	22·90	0·76	0·911	0·5075146	787	7	1122	19	552	56	0·5072641
138	17 30	32·332	13·40	17	23·80	0·76	0·906	0·5078536	787	8	1166	19	518	56	0·5076020
140	18 28	34·075	13·40	17	24·25	0·76	0·907	0·5074459	787	8	1188	19	550	56	0·5071889
													Mean	...	0·5073543
								Time of Vibration of Mean Pendulum						...	**0·5073558**
								Do. not applying lag correction						...	**0·5073554**
13-14 December, 1904.															
140	3 39	34·074	+14·04	16	22·97	−0·42	0·916	0·5074463	−824	−7	−1126	− 11	− 555	−56	0·5071884
138	4 39	32·321	14·04	17	22·57	0·42	0·920	0·5078565	824	8	1106	11	526	56	0·5076034
139	5 35	33·753	14·04	15	22·14	0·42	0·922	0·5075181	824	6	1085	11	559	56	0·5072640
137	6 34	33·344	14·04	16	21·78	0·42	0·923	0·5076117	824	7	1067	11	548	56	0·5073604
													Mean	...	0·5073541
140	15 45	34·129	+14·04	16	21·67	+0·54	0·916	0·5074341	−824	−7	−1062	+ 13	− 555	−56	0·5071850
138	16 40	32·332	14·04	17	22·30	0·54	0·914	0·5078538	824	8	1093	13	523	56	0·5076047
139	17 37	33·743	14·04	15	22·82	0·54	0·912	0·5075202	824	6	1118	13	553	56	0·5072658
137	18 34	33·315	14·04	17	23·20	0·54	0·910	0·5076185	824	8	1137	13	541	56	0·5073632
													Mean	...	0·5073547
								Time of Vibration of Mean Pendulum						...	**0·5073544**
								Do. not applying lag correction						...	**0·5073543**

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
								14-15 December, 1904.							
	h m	s	s	′	°	°		s							s
139	3 40	33·731	+14·16	17	22·67	−0·38	0·917	0·5075232	− 831	−8	−1111	− 10	− 556	−56	0·5072660
137	4 38	33·318	14·16	16	22·26	0·38	0·921	0·5076180	831	7	1091	10	547	56	0·5073638
140	5 34	34·086	14·16	15	21·90	0·38	0·921	0·5074433	831	6	1073	10	558	56	0·5071899
138	6 31	32·329	14·16	17	21·59	0·38	0·923	0·5078546	831	8	1058	10	528	56	0·5076055
													Mean	...	0·5073563
139	15 42	33·772	+14·16	15	21·33	+0·62	0·917	0·5075140	− 831	−6	−1045	+ 15	− 556	−56	0·5072661
137	16 36	33·336	14·16	17	21·99	0·62	0·914	0·5076135	831	8	1078	15	543	56	0·5073634
140	17 32	34·084	14·16	18	22·60	0·62	0·912	0·5074441	831	9	1107	15	553	56	0·5071900
138	18 30	32·314	14·16	15	23·05	0·62	0·910	0·5078582	831	6	1129	15	521	56	0·5076054
													Mean	...	0·5073562
									Time of Vibration of Mean Pendulum					...	**0·5073563**
									Do. not applying lag correction					...	**0·5073560**
								16-17 December, 1904.							
138	3 42	32·301	+14·38	18	22·39	−0·46	0·923	0·5078615	− 844	−9	−1097	− 11	− 528	−52	0·5076071
140	4 36	34·075	14·38	16	21·87	0·46	0·928	0·5074459	844	7	1072	11	562	52	0·5071911
137	5 33	33·318	14·38	16	21·45	0·46	0·929	0·5076176	844	7	1051	11	552	52	0·5073659
139	6 30	33·753	14·38	16	21·05	0·46	0·929	0·5075180	844	7	1031	11	563	52	0·5072672
													Mean	...	0·5073579
138	15 47	32·352	+14·38	17	21·06	+0·65	0·919	0·5078487	− 844	−8	−1032	+ 16	− 526	−52	0·5076041
140	16 44	34·106	14·38	16	21·89	0·65	0·916	0·5074392	844	7	1073	16	555	52	0·5071876
137	17 42	33·330	14·38	17	22·54	0·65	0·914	0·5076151	844	8	1104	16	543	52	0·5073616
139	18 39	33·739	14·38	16	23·00	0·65	0·911	0·5075212	844	7	1127	16	552	52	0·5072646
													Mean	...	0·5073545
									Time of Vibration of Mean Pendulum					...	**0·5073562**
									Do. not applying lag correction					...	**0·5073560**
									General Mean with lag correction					...	**0·5073557**
									„ without „					...	**0·5073554**
								Chatra.							
								30-31 December, 1904.							
	h m	s	s	′	°	°		s							s
137	3 39	33·505	+20·82	15	16·89	0·00	0·948	0·5075748	−1222	−6	− 828	No correction applied	− 563	−61	0·5073068
139	4 35	33·940	20·82	16	16·90	0·00	0·948	0·5074761	1222	7	828		574	61	0·5072069
138	5 34	32·496	20·82	17	16·93	0·00	0·948	0·5078136	1222	8	830		542	61	0·5075473
140	6 32	34·291	20·82	15	16·86	0·00	0·948	0·5073983	1222	6	826		574	61	0·5071294
													Mean	...	0·5072976
137	15 58	33·509	+20·82	15	17·68	+0·63	0·936	0·5075737	−1222	−6	− 866		− 556	−61	0·5073026
139	16 55	33·909	20·82	17	18·56	0·63	0·933	0·5074830	1222	8	909		565	61	0·5072065
138	17 55	32·459	20·82	16	19·10	0·63	0·930	0·5078226	1222	7	936		532	61	0·5075468
140	18 54	34·224	20·82	16	19·63	0·63	0·927	0·5074132	1222	7	962		562	61	0·5071318
													Mean	...	0·5072969
									Time of Vibration of Mean Pendulum					...	**0·5072973**
								31 Dec. 1904—1 Jan. 1905.							
140	3 44	34·228	+20·85	16	18·19	−0·35	0·942	0·5074123	−1224	−7	− 891	No correction applied	− 571	−61	0·5071369
138	4 45	32·451	20·85	17	17·84	0·35	0·945	0·5078247	1224	8	874		541	61	0·5075539
139	5 40	33·899	20·85	16	17·51	0·35	0·947	0·5074853	1224	7	858		574	61	0·5072129
137	6 42	33·484	20·85	15	17·21	0·35	0·948	0·5075795	1224	6	843		563	61	0·5073098
													Mean	...	0·5073034
140	16 4	34·311	+20·85	17	16·23	+0·90	0·944	0·5073941	−1224	−8	− 795		− 572	−61	0·5071281
138	17 1	32·505	20·85	16	17·05	0·90	0·939	0·5078113	1224	7	835		537	61	0·5075449
139	18 2	33·934	20·85	16	17·99	0·90	0·933	0·5074775	1224	7	882		565	61	0·5072036
137	19 2	33·485	20·85	17	18·87	0·90	0·929	0·5075793	1224	8	925		552	61	0·5073023
													Mean	...	0·5072947
									Time of Vibration of Mean Pendulum					...	**0·5072991**

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
	1-2 January, 1905.														
	h m	s	s	′	°	°		s							s
139	3 58	33·893	+21·37	16	17·70	−0·19	0·943	0·5074866	−1254	−7	−867	No correction applied	−571	−59	0·5072138
137	4 56	33·469	21·37	17	17·64	0·19	0·943	0·5075828	1254	8	864		560	59	0·5073083
140	5 53	34·240	21·37	16	17·44	0·19	0·945	0·5074095	1254	7	855		573	59	0·5071347
138	6 53	32·469	21·37	17	17·14	0·19	0·947	0·5078201	1254	8	840		542	59	0·5075498
													Mean	...	0·5073017
139	16 8	33·966	+21·37	16	15·46	+1·04	0·947	0·5074703	−1254	−7	−758		−574	−59	0·5072051
137	17 5	33·522	21·37	17	16·52	1·04	0·937	0·5075708	1254	8	809		557	59	0·5073021
140	18 4	34·267	21·37	16	17·64	1·04	0·932	0·5074035	1254	7	864		565	59	0·5071286
138	19 4	32·468	21·37	17	18·50	1·04	0·928	0·5078203	1254	8	907		531	59	0·5075444
													Mean	...	0·5072950
								Time of Vibration of Mean Pendulum						...	**0·5072984**
													General Mean	...	**0·5072983**
	Kisnapur.														
	17-18 January, 1905.														
	h m	s	s	′	°	°		s							s
137	5 25	33·896	+ 8·12	17	17·50	−0·34	0·940	0·5074860	− 477	− 8	− 858	No correction applied	− 558	−61	0·5072898
139	6 24	34·343	8·12	15	17·34	0·34	0·940	0·5073871	477	6	850		570	61	0·5071907
138	7 25	32·872	8·12	15	16·97	0·34	0·943	0·5077227	477	6	832		539	61	0·5075312
140	8 20	34·720	8·12	17	16·56	0·34	0·945	0·5073073	477	8	811		573	61	0·5071143
													Mean	...	0·5072815
137	17 40	33·977	+ 8·12	19	15·32	+0·79	0·939	0·5074677	− 477	−10	− 751		− 558	−61	0·5072820
139	18 37	34·395	8·12	16	16·31	0·79	0·935	0·5073757	477	7	799		567	61	0·5071846
138	19 38	32·902	8·12	16	17·09	0·79	0·932	0·5077153	477	7	837		533	61	0·5075238
140	20 35	35·877	8·12	15	17·69	0·79	0·929	0·5073056	477	6	867		563	61	0·5071082
													Mean	...	0·5072747
								Time of Vibration of Mean Pendulum						...	**0·5072781**
	18-19 January, 1905.														
140	5 34	34·708	+ 8·12	16	17·26	−0·11	0·938	0·5073081	− 477	− 7	− 846	No correction applied	− 568	−61	0·5071122
138	6 35	32·879	8·12	17	17·17	0·11	0·939	0·5077210	477	8	841		537	61	0·5075286
139	7 31	34·362	8·12	17	17·06	0·11	0·939	0·5073830	477	8	836		569	61	0·5071879
137	8 33	33·927	8·12	18	16·93	0·11	0·940	0·5074790	477	9	830		558	61	0·5072855
													Mean	...	0·5072786
140	17 38	34·739	+ 8·12	16	16·25	+0·80	0·941	0·5073015	− 477	− 7	− 796		− 570	−61	0·5071104
138	18 35	32·896	8·12	17	16·97	0·80	0·934	0·5077168	477	8	832		534	61	0·5075256
139	19 34	34·359	8·12	16	17·83	0·80	0·929	0·5073836	477	7	874		563	61	0·5071854
137	20 34	33·902	8·12	15	18·59	0·80	0·927	0·5074846	477	6	911		551	61	0·5072840
													Mean	...	0·5072764
								Time of Vibration of Mean Pendulum						...	**0·5072775**
	19-20 January, 1905.														
139	5 35	34·336	+ 8·12	17	18·02	−0·06	0·933	0·5073886	− 477	− 8	− 883	No correction applied	− 565	−57	0·5071896
137	6 33	33·903	8·12	16	17·91	0·06	0·933	0·5074843	477	7	878		554	57	0·5072870
140	7 34	34·692	8·12	17	17·88	0·06	0·933	0·5073117	477	8	876		565	57	0·5071134
138	8 32	32·868	8·12	17	17·84	0·06	0·933	0·5077237	477	8	874		534	57	0·5075287
													Mean	...	0·5072797
139	17 50	34·368	+ 8·12	17	17·07	+0·75	0·931	0·5073815	− 477	− 8	− 836		− 564	−57	0·5071873
137	18 51	33·918	8·12	16	17·91	0·75	0·928	0·5074810	477	7	878		551	57	0·5072840
140	17 50	34·686	8·12	17	18·59	0·75	0·923	0·5073129	477	8	911		559	57	0·5071117
138	20 49	32·854	8·12	18	19·23	0·75	0·921	0·5077271	477	9	942		527	57	0·5075259
													Mean	...	0·5072772
								Time of Vibration of Mean Pendulum						...	**0·5072785**
													Mean 17-20 January	...	**0·5072780**

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature		Density of Air	Observed Time of Vibration	Correction on account of						Reduced Time of Vibration
					Corrected Mean	Mean change per hour			Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	
						Kisnapur.									
						21-22 January, 1905.									
	h m	s	s	′	°	°		s							s
138	5 49	32·875	+ 8·51	17	17·32	−0·13	0·938	0·5077220	− 500	− 8	− 849	No correction applied	− 537	−56	0·5075270
140	6 43	34·704	8·51	16	17·19	0·13	0·938	0·5073091	500	7	842		568	56	0·5071118
137	7 41	33·920	8·51	16	17·10	0·13	0·939	0·5074807	500	7	838		558	56	0·5072848
139	8 40	34·363	8·51	16	16·89	0·13	0·939	0·5073826	500	7	828		569	56	0·5071866
													Mean	...	0·5072776
138	17 50	32·911	+ 8·51	17	16·17	+1·18	0·937	0·5077135	− 500	− 8	− 792		− 536	−56	0·5075243
140	18 47	34·723	8·51	17	16·99	1·18	0·931	0·5073049	500	8	833		564	56	0·5071088
137	19 47	33·910	8·51	17	18·26	1·18	0·924	0·5074827	500	8	895		549	56	0·5072819
139	20 45	34·321	8·51	17	19·39	1·18	0·920	0·5073917	500	8	950		558	56	0·5071845
													Mean	...	0·5072749
								Time of Vibration of Mean Pendulum						...	**0·5072762**
						22-23 January, 1905.									
140	5 50	34·657	+ 8·51	17	18·39	−0·26	0·930	0·5073191	− 500	− 8	− 901	No correction applied	− 564	−57	0·5071161
138	6 49	32·839	8·51	17	18·37	0·26	0·931	0·5077308	500	8	900		533	57	0·5075310
139	7 48	34·322	8·51	16	18·02	0·26	0·933	0·5073916	500	7	883		565	57	0·5071904
137	8 45	33·890	8·51	16	17·72	0·26	0·934	0·5074873	500	7	868		555	57	0·5072886
													Mean	...	0·5072815
140	18 4	34·717	+ 8·51	17	16·69	+0·54	0·932	0·5073062	− 500	− 8	− 818		− 565	−57	0·5071114
138	19 2	32·880	8·51	17	17·09	0·54	0·931	0·5077209	500	8	837		533	57	0·5075274
139	19 58	34·348	8·51	17	17·58	0·54	0·927	0·5073859	500	8	861		563	57	0·5071871
137	20 57	33·896	8·51	17	18·25	0·54	0·923	0·5074860	500	8	894		548	57	0·5072853
													Mean	...	0·5072778
								Time of Vibration of Mean Pendulum						...	**0·5072797**
											Mean 21—23 January			...	**0·5072780**
											General Mean			..	**0·5072780**
						Jalpaiguri.									
						31 January—1 February, 1905.									
	h m	s	s	′	°	°		s							s
137	7 5	33·629	+19·69	17	15·06	+0·04	0·934	0·5075463	−1156	− 8	− 738	+ 1	− 555	−50	0·5072957
139	8 18	34·054	19·69	17	15·15	0·04	0·934	0·5074507	1156	8	742	1	566	50	0·5071986
138	9 28	32·603	19·69	18	15·18	0·04	0·935	0·5077876	1156	9	744	1	535	50	0·5075383
140	10 29	34·397	19·69	17	15·21	0·04	0·934	0·5073752	1156	8	745	1	566	50	0·5071228
													Mean	...	0·5072889
137	19 8	33·637	+19·69	18	14·47	+0·12	0·943	0·5075445	−1156	− 9	− 709	+ 3	− 560	−46	0·5072968
139	20 7	34·070	19·69	16	14·65	0·12	0·939	0·5074472	1156	7	718	3	569	46	0·5071979
138	21 15	32·613	19·69	16	14·77	0·12	0·939	0·5077850	1156	7	724	3	537	46	0·5075383
140	22 14	34·403	19·69	15	14·87	0·12	0·938	0·5073741	1156	6	729	3	568	46	0·5071239
													Mean	...	0·5072892
								Time of Vibration of Mean Pendulum						...	**0·5072890**
						1-2 February, 1905.									
140	6 32	34·402	+20·09	18	14·77	+0·01	0·940	0·5073741	−1179	− 9	− 724	0	− 570	−44	0·5071215
138	7 35	32·605	20·09	20	14·83	0·01	0·939	0·5077870	1179	11	727	0	537	44	0·5075372
139	8 38	34·062	20·09	16	14·83	0·01	0·941	0·5074490	1179	7	727	0	570	44	0·5071963
137	9 48	33·626	20·09	15	14·81	0·01	0·940	0·5075469	1179	6	726	0	558	44	0·5072956
													Mean	...	0·5072877
140	19 10	34·980	+20·09	17	14·40	+0·10	0·942	0·5073732	−1179	− 8	− 706	+ 3	− 571	−44	0·5071227
138	20 15	32·613	20·09	17	14·52	0·10	0·941	0·5077851	1179	8	711	3	538	44	0·5075374
139	21 18	34·062	20·09	18	14·60	0·10	0·940	0·5074488	1179	9	715	3	570	44	0·5071974
137	22 21	33·630	20·09	15	14·73	0·10	0·939	0·5075461	1179	6	722	3	558	44	0·5072955
													Mean	...	0·5072882
								Time of Vibration of Mean Pendulum						...	**0·5072880**

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
								2-3 February, 1905.							
	h m	s	s	′	°	°		s							s
139	6 27	34·064	+20·35	16	14·34	+0·02	0·943	0·5074485	−1195	−7	−703	+1	−571	−43	0·5071967
137	7 41	33·632	20·35	12	14·37	0·02	0·943	0·5075455	1195	4	704	1	560	43	0·5072950
140	8 44	34·407	20·35	13	14·38	0·02	0·941	0·5073731	1195	5	705	1	570	43	0·3071214
138	9 47	32·610	20·35	17	14·42	0·02	0·941	0·5077858	1195	8	707	1	538	43	0·5075368
													Mean	...	0·5072875
139	19 4	34·066	+20·35	17	14·13	+0·09	0·944	0·5074480	−1195	−8	−692	+2	−572	−42	0·5071973
137	20 9	33·645	20·35	14	14·28	0·09	0·944	0·5075426	1195	5	700	2	561	42	0·5072925
140	21 11	34·409	20·35	16	14·37	0·09	0·943	0·5073727	1195	7	704	2	571	42	0·5071210
138	22 18	32·611	20·35	16	14·43	0·09	0·940	0·5077855	1195	7	707	2	538	42	0·5075368
													Mean	...	0·5072869
											Time of Vibration of Mean Pendulum			...	**0·5072872**
													General Mean	...	**0·5072881**
								Kesarbari.							
								14-15 February, 1905.							
	h m	s	s	′	°	°		s							s
137	7 49	34·122	+ 2·16	17	15·92	+0·13	0·937	0·5074356	−127	−8	−780	+3	−557	−71	0·5072816
139	8 47	34·563	2·16	15	15·98	0·13	0·937	0·5073393	127	6	783	3	568	71	0·5071841
138	9 45	33·071	2·16	15	16·10	0·13	0·934	0·5076755	127	6	789	3	534	71	0·5075231
140	10 42	34·911	2·16	15	16·30	0·13	0·933	0·5072652	127	6	799	3	565	71	0·5071087
													Mean	...	0·5072744
137	19 57	34·128	+ 2·16	15	15·24	+0·49	0·934	0·5074345	−127	−6	−747	+12	−555	−71	0·5072851
139	20 56	34·570	2·16	14	15·82	0·49	0·934	0·5073379	127	5	775	12	566	71	0·5071847
138	21 54	33·055	2·16	14	16·53	0·49	0·934	0·5076793	127	5	809	12	534	71	0·5075259
140	22 46	34·899	2·16	14	16·40	0·49	0·935	0·5072676	127	5	804	12	567	71	0·5071114
													Mean	...	0·5072768
											Time of Vibration of Mean Pendulum			...	**0·5072756**
											Do. not applying lag correction			...	**0·5072748**
								15-16 February, 1905.							
140	6 59	34·900	+ 2·16	13	16·04	+0·17	0·938	0·5072675	−127	−5	−786	+4	−568	−71	0·5071122
138	7 58	33·052	2·16	16	16·26	0·17	0·938	0·5076800	127	7	797	4	537	71	0·5075265
139	8 56	34·537	2·16	16	16·40	0·17	0·937	0·5073450	127	7	804	4	568	71	0·5071877
137	9 55	34·093	2·16	14	16·55	0·17	0·935	0·5074421	127	5	811	4	555	71	0·5072856
													Mean	...	0·5072780
140	19 53	34·897	+ 2·16	16	15·98	+0·32	0·937	0·5072681	−127	−7	−783	+8	−568	−71	0·5071133
138	20 49	33·043	2·16	17	16·35	0·32	0·934	0·5076821	127	8	801	8	534	71	0·5075288
139	21 43	34·524	2·16	16	16·72	0·32	0·933	0·5073478	127	7	819	8	565	71	0·5071897
137	22 40	34·077	2·16	16	16·84	0·32	0·933	0·5074456	127	7	825	8	554	71	0·5072880
													Mean	...	0·5072799
											Time of Vibration of Mean Pendulum			...	**0·5072790**
											Do. not applying lag correction			...	**0·5072784**
								16-17 February, 1905.							
137	7 14	34·074	+ 2·17	18	16·74	+0·07	0·934	0·5074463	−127	−9	−820	+2	−555	−71	0·5072883
139	8 9	34·529	2·17	19	16·84	0·07	0·934	0·5073467	127	10	825	2	566	71	0·5071870
138	9 5	33·024	2·17	16	16·90	0·07	0·934	0·5076867	127	7	828	2	534	71	0·5075302
140	10 0	34·865	2·17	15	16·93	0·07	0·937	0·5072748	127	6	830	2	568	71	0·5171148
													Mean	...	0·5072801
137	20 18	34·076	+ 2·17	17	16·51	+0·17	0·934	0·5074458	−127	−8	−809	+4	−555	−71	0·5072892
139	21 12	34·514	2·17	16	16·89	0·17	0·931	0·5073500	127	7	828	4	564	71	0·5071907
138	22 10	33·019	2·17	15	16·97	0·17	0·931	0·5076880	127	6	832	4	533	71	0·5075315
140	22 5	34·854	2·17	15	17·09	0·17	0·931	0·5072771	127	6	837	4	564	71	0·5071170
													Mean	...	0·5072821
											Time of Vibration of Mean Pendulum			...	**0·5072811**
											Do. not applying lag correction			...	**0·5072808**

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
								17-18 February, 1905.							
	h m	s	s	′	°	°		s							s
140	7 18	34·853	+ 2·17	16	17·18	+0·14	0·933	0·5072773	−127	−7	− 842	+ 4	− 565	−71	0·5071165
138	8 17	33·005	2·17	16	17·35	0·14	0·931	0·5076911	127	7	850	4	533	71	0·5075327
139	9 11	34·494	2·17	15	17·48	0·14	0·932	0·5073542	127	6	857	4	565	71	0·5071920
137	10 8	34·050	2·17	15	17·58	0·14	0·932	0·5074516	127	6	861	4	554	71	0·5072901
													Mean	...	0·5072828
140	20 5	34·836	+ 2·17	16	17·35	+0·35	0·931	0·5072811	−127	−7	− 850	+ 9	− 564	−71	0·5071201
138	21 6	32·995	2·17	16	17·75	0·35	0·931	0·5076935	127	7	870	9	533	71	0·5075336
139	22 2	34·473	2·17	16	18·11	0·35	0·926	0·5073588	127	7	887	9	561	71	0·5071944
137	23 10	34·021	2·17	14	18·38	0·35	0·924	0·5074580	127	5	901	9	549	71	0·5072936
													Mean	...	0·5072854
													Time of Vibration of Mean Pendulum	...	0·5072841
													Do. not applying lag correction	...	0·5072835
													General Mean with "	...	0·5072799
													" without "	...	0·5072794
								Ramchandpur. 25-26 February, 1905.							
	h m	s	s	′	°	°		s							s
137	8 44	34·143	− 0·84	16	17·65	−0·04	0·932	0·5074309	+ 49	−7	− 865	− 1	− 554	−69	0·5072862
139	9 42	34·588	0·84	16	17·51	0·04	0·933	0·5073340	49	7	858	1	565	69	0·5071889
138	10 39	33·096	0·84	15	17·46	0·04	0·932	0·5076698	49	6	856	1	533	69	0·5075282
140	11 35	34·969	0·84	16	17·56	0·04	0·932	0·5072529	49	7	860	1	565	69	0·5071076
													Mean	...	0·5072777
137	20 34	34·172	− 0·84	17	17·24	+0·39	0·931	0·5074245	+ 49	−8	− 845	+ 10	− 553	−69	0·5072829
139	21 27	34·605	0·84	16	17·63	0·39	0·929	0·5073303	49	7	864	10	563	69	0·5071859
138	22 22	33·100	0·84	17	17·99	0·39	0·926	0·5076688	49	8	882	10	530	69	0·5075258
140	22 18	34·950	0·84	16	18·28	0·39	0·924	0·5072568	49	7	896	10	560	69	0·5071095
													Mean	...	0·5072760
													Time of Vibration of Mean Pendulum	...	0·5072769
													Do. not applying lag correction	...	0·5072764
								26-27 February, 1905.							
140	7 51	34·934	− 0·18	16	17·90	−0·09	0·932	0·5072603	+ 12	−7	− 877	− 2	− 565	−68	0·5071096
138	8 48	33·092	0·18	15	17·83	0·09	0·933	0·5076707	12	6	874	2	534	68	0·5075335
139	9 56	34·641	0·18	15	17·71	0·09	0·933	0·5073226	12	6	868	2	565	68	0·5071729
137	10 53	34·143	0·18	15	17·67	0·09	0·933	0·5074312	12	6	866	2	554	68	0·5072828
													Mean	...	0·5072722
140	20 15	34·915	− 0·18	16	19·38	+0·10	0·925	0·5072643	+ 12	−7	− 950	+ 3	− 561	−68	0·5071072
138	21 13	33·063	0·18	18	19·39	0·10	0·934	0·5076773	12	9	950	3	534	68	0·5075227
139	22 9	34·544	0·18	15	19·49	0·10	0·933	0·5073435	12	6	955	3	565	68	0·5071856
137	23 11	34·101	0·18	15	19·66	0·10	0·932	0·5074403	12	6	963	3	554	68	0·5072827
													Mean	...	0·5072746
													Time of Vibration of Mean Pendulum	...	0·5072734
													Do. not applying lag correction	...	0·5072733
								27-28 February, 1905.							
139	7 48	34·519	+ 0·71	16	18·93	−0·01	0·927	0·5073490	− 42	−7	− 928	0	− 562	−66	0·5071885
137	8 44	34·086	0·71	15	18·91	0·01	0·926	0·5074436	42	6	927	0	550	66	0·5072845
140	9 42	34·884	0·71	16	18·87	0·01	0·927	0·5072708	42	7	925	0	562	66	0·5071106
138	10 41	33·038	0·71	15	18·93	0·01	0·926	0·5076832	42	6	928	0	530	66	0·5075260
													Mean	...	0·5072774
139	20 24	34·513	+ 0·71	16	20·08	+0·32	0·921	0·5073501	− 42	−7	− 984	+ 8	− 558	−66	0·5071852
137	21 27	34·062	0·71	15	20·24	0·32	0·918	0·5074490	42	6	992	8	545	66	0·5072847
140	22 34	34·853	0·71	15	20·64	0·32	0·915	0·5072773	42	6	1011	8	554	66	0·5071102
138	23 39	33·003	0·71	15	21·02	0·32	0·913	0·5076916	42	6	1030	8	522	66	0·5075258
													Mean	...	0·5072765
													Time of Vibration of Mean Pendulum	...	0·5072769
													Do. not applying lag correction	...	0·5072765

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Correction: Arc	Correction: Temperature	Correction: Lag	Correction: Density of Air	Correction: Flexure	Reduced Time of Vibration
								Siliguri.							
								12-13 March, 1905.							
	h m	s	s	′	°	°		s							s
137	9 28	33·980	+ 1·79	16	18·97	+0·01	0·913	0·5074672	−105	−7	− 930	0	− 542	−64	0·5073024
139	10 23	34·415	1·79	17	19·07	0·01	0·910	0·5073712	105	8	934	0	551	64	0·5072050
138	11 20	32·934	1·79	16	19·06	0·01	0·910	0·5077080	105	7	934	0	521	64	0·5075449
140	12 19	34·767	1·79	15	19·01	0·01	0·912	0·5072957	105	6	931	0	553	64	0·5071298
													Mean	...	0·5072955
137	21 41	33·992	+ 1·79	18	18·41	+0·41	0·914	0·5074646	−105	−9	− 902	+ 10	− 543	−64	0·5073033
139	22 34	34·422	1·79	18	18·73	0·41	0·912	0·5073699	105	9	918	10	553	64	0·5072060
138	23 35	32·930	1·79	16	19·13	0·41	0·909	0·5077090	105	7	937	10	520	64	0·5075467
140	0 31	34·748	1·79	15	19·56	0·41	0·906	0·5072996	105	6	958	10	549	64	0·5071324
													Mean	...	0·5072971
										Time of Vibration of Mean Pendulum				...	**0·5072963**
										Do. not applying lag correction				...	**0·5072958**
								13-14 March, 1905.							
140	9 6	34·718	+ 2·57	14	19·83	+0·02	0·912	0·5073060	−151	−5	− 972	+ 1	− 553	−64	0·5071316
138	10 5	32·892	2·57	16	19·81	0·02	0·912	0·5077179	151	7	971	1	522	64	0·5075465
139	11 1	34·376	2·57	14	19·80	0·02	0·912	0·5073798	151	5	970	1	553	64	0·5072056
137	12 4	33·933	2·57	16	19·89	0·02	0·912	0·5074777	151	7	975	1	542	64	0·5073039
													Mean	...	0·5072969
140	21 32	34·729	+ 2·57	17	19·56	+0·33	0·913	0·5073038	−151	−8	− 958	+ 8	− 553	−64	0·5071312
138	22 28	32·894	2·57	18	19·82	0·33	0·910	0·5077173	151	9	971	8	521	64	0·5075465
139	23 26	34·371	2·57	16	20·14	0·33	0·907	0·5073810	151	7	987	8	550	64	0·5072059
137	0 25	33·922	2·57	15	20·49	0·33	0·905	0·5074800	151	5	1004	8	538	64	0·5073045
													Mean	...	0·5072970
										Time of Vibration of Mean Pendulum				...	**0·5072970**
										Do. not applying lag correction				...	**0·5072965**
								14-15 March, 1905.							
139	8 50	34·348	+ 2·80	16	20·48	−0·04	0·908	0·5073859	−164	−7	−1004	− 1	− 550	−64	0·5072069
137	9 47	33·910	2·80	16	20·43	0·04	0·908	0·5074828	164	7	1001	1	539	64	0·5073052
140	10 42	34·701	2·80	16	20·40	0·04	0·908	0·5073098	164	7	1000	1	550	64	0·5071312
138	11 38	32·872	2·80	17	20·36	0·04	0·908	0·5077228	164	8	998	1	519	64	0·5075474
													Mean	...	0·5072977
139	21 24	34·363	+ 2·80	16	19·84	+0·32	0·911	0·5073826	−164	−7	− 972	+ 8	− 552	−64	0·5072075
137	22 18	33·918	2·80	16	20·03	0·32	0·908	0·5074810	164	7	981	8	539	64	0·5073063
140	23 14	34·701	2·80	15	20·30	0·32	0·906	0·5073097	164	6	995	8	549	64	0·5071327
138	0 12	32·869	2·80	16	20·80	0·32	0·903	0·5077236	164	7	1019	8	517	64	0·5075473
													Mean	...	0·5072984
										Time of Vibration of Mean Pendulum				...	**0·5072980**
										Do. not applying lag correction				...	**0·5072977**
								15-16 March, 1905.							
138	9 21	32·846	+ 3·47	16	21·03	−0·09	0·907	0·5077290	−204	−7	−1030	− 2	− 519	−64	0·5075464
140	10 13	34·672	3·47	14	20·88	0·09	0·907	0·5073160	204	5	1023	2	550	64	0·5071312
137	11 10	33·886	3·47	14	20·80	0·09	0·906	0·5074880	204	5	1019	2	538	64	0·5073048
139	12 5	34·323	3·47	15	20·78	0·09	0·906	0·5073915	204	6	1018	2	549	64	0·5072072
													Mean	...	0·5072974
138	21 37	32·849	+ 3·47	17	20·75	+0·32	0·905	0·5077282	−204	−8	−1017	+ 8	− 518	−64	0·5075479
140	22 30	34·688	3·47	16	20·98	0·32	0·903	0·5073127	204	7	1028	8	547	64	0·5071285
137	23 25	33·901	3·47	15	21·28	0·32	0·900	0·5074849	204	6	1043	8	535	64	0·5073005
139	0 26	34·338	3·47	17	21·65	0·32	0·897	0·5073883	204	8	1061	8	544	64	0·5072010
													Mean	...	0·5072945
										Time of Vibration of Mean Pendulum				...	**0·5072960**
										Do. not applying lag correction				...	**0·5072957**

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
	Darjeeling.														
	20-21 March, 1905.														
	h m	s	s	′	°	°		s							s
137	10 11	33·571	+ 7·13	19	12·75	+0·09	0·735	0·5075596	−419	−10	− 625	+ 2	− 437	−57	0·5074050
139	11 10	33·998	7·13	18	12·91	0·09	0·735	0·5074633	419	9	633	2	445	57	0·5073072
138	12 5	32·550	7·13	18	12·97	0·09	0·735	0·5078003	419	9	636	2	420	57	0·5076464
140	12 59	34·334	7·13	16	13·02	0·09	0·735	0·5073891	419	7	638	2	445	57	0·5072327
													Mean	...	0·5073978
137	22 20	33·558	+ 7·13	17	13·34	+0·05	0·738	0·5075623	−419	− 8	− 654	+ 1	− 438	−57	0·5074048
139	23 18	33·989	7·13	17	13·18	0·05	0·737	0·5074651	419	8	646	1	447	57	0·5073075
138	0 16	32·550	7·13	16	13·33	0·05	0·736	0·5078003	419	7	653	1	421	57	0·5076447
140	1 25	34·336	7·13	15	13·38	0·05	0·735	0·5073887	419	6	656	1	445	57	0·5072305
													Mean	...	0·5073969
								Time of Vibration of Mean Pendulum						...	**0·5073974**
	21-22 March, 1905.														
140	9 4	34·324	+ 7·38	17	13·49	+0·02	0·734	0·5073916	−433	− 8	− 661	+ 1	− 445	−57	0·5072307
138	9 59	32·537	7·38	16	13·43	0·02	0·734	0·5078033	433	7	658	1	420	57	0·5076459
139	10 55	33·980	7·38	17	13·43	0·02	0·734	0·5074672	433	8	658	1	445	57	0·5073072
137	11 50	33·553	7·38	17	13·54	0·02	0·734	0·5075636	433	8	663	1	436	57	0·5074040
													Mean	...	0·5073969
140	21 55	34·322	+ 7·38	17	13·48	−0·01	0·734	0·5073916	−433	− 8	− 661	0	− 445	−57	0·5072312
138	22 52	32·532	7·38	17	13·56	0·01	0·734	0·5078047	433	8	664	0	420	57	0·5076465
139	23 51	33·981	7·38	17	13·49	0·01	0·734	0·5074667	433	8	661	0	445	57	0·5073063
137	0 49	33·549	7·38	17	13·51	0·01	0·734	0·5075646	433	8	662	0	436	57	0·5074050
													Mean	...	0·5073973
								Time of Vibration of Mean Pendulum						...	**0·5073971**
	22-23 March, 1905.														
139	9 6	33·986	+ 7·19	17	13·33	+0·03	0·735	0·5074658	−422	− 8	− 653	+ 1	− 445	−57	0·5073074
137	10 6	33·554	7·19	17	13·44	0·03	0·734	0·5075635	422	8	659	1	436	57	0·5074054
140	11 1	34·325	7·19	16	13·45	0·03	0·737	0·5073909	422	7	659	1	447	57	0·5072318
138	11 57	32·536	7·19	17	13·42	0·03	0·737	0·5078038	422	8	658	1	422	57	0·5076472
													Mean	...	0·5073979
139	22 8	33·994	+ 7·19	18	13·29	+0·04	0·736	0·5074641	−422	− 9	− 651	+ 1	− 446	−57	0·5073057
137	23 5	33·559	7·19	17	13·51	0·04	0·735	0·5075622	422	8	662	1	437	57	0·5074037
140	0 3	34·327	7·19	16	13·54	0·04	0·736	0·5073907	422	7	663	1	446	57	0·5072313
138	1 1	32·540	7·19	16	13·40	0·04	0·734	0·5078027	422	7	657	1	420	57	0·5076465
													Mean	...	0·5073968
								Time of Vibration of Mean Pendulum						...	**0·5073974**
	Kurseong.														
	27-28 March, 1905.														
	h m	s	s	′	°	°		s							s
137	10 36	33·632	+ 8·43	19	15·05	−0·01	0·787	0·5075455	−495	−10	− 737	0	− 467	−35	0·5073711
139	11 34	34·062	8·43	17	15·08	0·01	0·786	0·5074488	495	8	739	0	476	35	0·5072735
138	12 31	32·616	8·43	16	15·08	0·01	0·786	0·5077843	495	7	739	0	450	35	0·5076117
140	13 24	34·405	8·43	17	15·04	0·01	0·686	0·5073735	495	8	737	0	476	35	0·5071984
													Mean	...	0·5073637
137	22 34	33·616	+ 8·43	17	15·73	+0·13	0·785	0·5075491	−495	− 8	− 771	+ 3	− 466	−35	0·5073719
139	23 30	34·042	8·43	16	15·77	0·13	0·784	0·5074532	495	7	773	3	475	35	0·5072750
138	0 26	32·590	8·43	15	15·91	0·13	0·784	0·5077906	495	6	780	3	448	35	0·4076105
140	1 21	34·374	8·43	14	16·09	0·13	0·782	0·5073803	495	5	788	3	474	35	0·5072009
													Mean	...	0·5073646
								Time of Vibration of Mean Pendulum						...	**0·5073641**

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
								28-29 March, 1905.							
	h m	s	s	′	°	°		s							s
140	9 56	34·358	+ 8·98	14	16·50	−0·10	0·784	0·5073837	−527	−5	− 809	− 3	− 475	−35	0·5071983
138	10 53	32·570	8·98	18	16·40	0·10	0·784	0·5077953	527	9	804	3	448	35	0·5076127
139	11 47	34·019	8·98	16	16·33	0·10	0·784	0·5074585	527	7	800	3	475	35	0·5072738
137	12 43	33·595	8·98	14	16·21	0·10	0·782	0·5075542	527	5	794	3	465	35	0·5073713
													Mean	...	0·5073640
140	22 31	34·352	+ 8·98	17	16·59	+0·12	0·783	0·5073852	−527	−8	− 813	+ 3	− 474	−35	0·5071998
138	23 29	32·566	8·98	16	16·65	0·12	0·781	0·5077965	527	7	816	3	447	35	0·5076136
139	0 24	34·010	8·98	16	16·77	0·12	0·781	0·5074606	527	7	822	3	473	35	0·5072745
137	1 22	33·575	8·98	15	16·91	0·12	0·778	0·5075586	527	6	829	3	462	35	0·5073730
													Mean	...	0·5073652
													Time of Vibration of Mean Pendulum	...	**0·5073646**
								29-30 March, 1905.							
139	9 46	34·007	+ 9·03	18	16·64	−0·03	0·780	0·5074610	−530	−9	− 815	− 1	− 473	−35	0·5072747
137	10 42	33·581	9·03	16	16·67	0·03	0·781	0·5075572	530	7	817	1	464	35	0·5073718
140	11 38	34·347	9·03	16	16·59	0·03	0·779	0·5073861	530	7	813	1	472	35	0·5072003
138	12 34	32·563	9·03	18	16·62	0·03	0·779	0·5077973	530	9	814	1	446	35	0·5076138
													Mean	...	0·5073652
139	22 38	34·010	+ 9·03	16	16·44	+0·17	0·781	0·5074606	−530	−7	− 806	+ 4	− 473	−35	0·5072759
137	23 33	33·582	9·03	14	16·54	0·17	0·781	0·5075571	530	5	810	4	464	35	0·5073731
140	0 35	34·344	9·03	14	16·74	0·17	0·778	0·5073868	530	5	820	4	471	35	0·5072011
138	1 32	32·554	9·03	16	16·88	0·17	0·778	0·5077995	530	7	827	4	445	35	0·5076155
													Mean	...	0·5073664
													Time of Vibration of Mean Pendulum	...	**0·5073658**
								31 March—1 April, 1905.							
138	9 55	32·558	+ 9·73	15	15·70	−0·06	0·781	0·5077983	−571	−6	− 769	− 2	− 447	−35	0·5076153
140	10 50	34·347	9·73	15	15·66	0·06	0·781	0·5073860	571	6	767	2	473	35	0·5072006
137	11 47	33 581	9·73	14	15·65	0·06	0·781	0·5075572	571	5	767	2	464	35	0·5073728
139	12 43	34·014	9·73	17	15·48	0·06	0·781	0·5074595	571	8	759	2	473	35	0·5072747
													Mean	...	0·5073659
138	22 58	32·594	+ 9·73	16	14·93	+0·27	0·781	0·5077897	−571	−7	− 732	+ 7	− 447	−35	0·5076112
140	23 57	34·371	9·73	15	15·37	0·27	0·781	0·5073811	571	6	753	7	473	35	0·5071980
137	0 52	33·595	9·73	14	15·59	0·27	0·780	0·5075541	571	5	764	7	463	35	0·5073710
139	1 51	34·020	9·73	15	15·79	0·27	0·780	0·5074581	571	6	774	7	473	35	0·5072729
													Mean	...	0·5073633
													Time of Vibration of Mean Pendulum	...	**0·5073646**
								Sandakphu.							
								10-11 April, 1905.							
	h m	s	s	′	°	°		s							s
137	1 49	33·472	+3·295	15	7·32	+0·08	0·627	0·5075823	−193	−6	− 359	+ 2	− 372	−47	0·5074848
139	2 44	33·894	3·295	17	7·49	0·08	0·627	0·5074863	193	8	367	2	380	47	0·5073870
138	3 44	32·456	3·295	16	7·54	0·08	0·628	0·5078231	193	7	369	2	359	47	0·5077258
140	4 40	34·229	3·295	15	7·59	0·08	0·627	0·5074120	193	6	372	2	380	47	0·5073124
													Mean	...	0·5074775
137	13 30	33·451	+3·295	14	8·31	+0·02	0·629	0·5075871	−193	−5	− 407	+ 1	− 374	−47	0·5074846
139	14 24	33·878	3·295	16	7·95	0·02	0·628	0·5074900	193	7	390	1	381	47	0·5073883
138	15 20	32·445	3·295	17	8·12	0·02	0·628	0·5078260	193	8	398	1	359	47	0·5077256
140	16 18	34·218	3·295	13	8·19	0·02	0·627	0·5074146	193	5	401	1	380	47	0·5073121
													Mean	...	0·5074777
													Time of Vibration of Mean Pendulum	...	**0·5074776**

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
11-12 April, 1905.															
	h m	s	s	′	°	°		s							s
140	22 46	34·209	+3·233	15	8·49	−0·07	0·627	0·5074165	−190	−6	−416	−2	−380	−47	0·5073124
138	23 43	32·430	3·233	17	8·50	0·07	0·627	0·5078297	190	8	417	2	359	47	0·5077274
139	0 41	33·870	3·233	16	8·37	0·07	0·627	0·5074917	190	7	410	2	380	47	0·5073881
137	1 38	33·445	3·233	14	8·34	0·07	0·627	0·5075883	190	5	409	2	372	47	0·5074858
													Mean	...	0·5074784
140	10 59	34·211	+3·233	16	8·43	−0·03	0·626	0·5074159	−190	−7	−413	−1	−379	−47	0·5073122
138	11 57	32·436	3·233	16	8·40	0·03	0·627	0·5078282	190	7	412	1	359	47	0·5077266
139	12 55	33·879	3·233	16	8·28	0·03	0·627	0·5074898	190	7	406	1	380	47	0·5073867
137	13 54	33·452	3·233	14	8·44	0·03	0·626	0·5075868	190	5	414	1	372	47	0·5074839
													Mean	...	0·5074774
									Time of Vibration of Mean Pendulum					...	**0·5074779**
12-13 April, 1905.															
139	23 16	33·870	+3·233	17	8·48	+0·05	0·625	0·5074917	−190	−8	−416	+1	−379	−47	0·5073878
137	0 15	33·450	3·233	15	8·48	0·05	0·625	0·5075872	190	6	416	1	371	47	0·5074843
140	1 13	34·209	3·233	16	8·47	0·05	0·624	0·5074163	190	7	415	1	378	47	0·5073127
138	2 10	32·435	3·233	17	8·67	0·05	0·624	0·5078282	190	8	425	1	357	47	0·5077256
													Mean	...	0·5074776
139	11 24	33·865	+3·233	17	8·80	−0·05	0·624	0·5074929	−190	−8	−431	−1	−378	−47	0·5073874
137	12 22	33·444	3·233	14	8·78	0·05	0·625	0·5075887	190	5	430	1	371	47	0·5074843
140	13 19	34·202	3·233	15	8·68	0·05	0·625	0·5074179	190	6	425	1	379	47	0·5073131
138	14 18	32·428	3·233	18	8·72	0·05	0·626	0·5078301	190	9	427	1	358	47	0·5077269
													Mean	...	0·5074779
									Time of Vibration of Mean Pendulum					...	**0·5074778**
Dehra Dun—*Field Station* (*Tent*).															
12-13 May, 1905.															
	h m	s	s	′	°	°		s							s
137	13 30	33·856	+7·65	16	27·85	−0·21	0·832	0·5074948	−449	−7	−1365	No correction applied	−494	−37	0·5072596
139	14 28	34·297	7·65	17	27·54	0·21	0·833	0·5073971	449	8	1349		505	37	0·5071623
138	15 27	32·828	7·65	18	27·37	0·21	0·833	0·5077333	449	9	1341		476	37	0·5075021
140	16 21	34·652	7·65	16	27·26	0·21	0·834	0·5073203	449	7	1336		505	37	0·5070869
													Mean	...	0·5072527
137	1 21	33·869	+7·65	17	28·32	+0·45	0·825	0·5074918	−449	−8	−1388		−490	−37	0·5072546
139	2 17	34·290	7·65	17	28·90	0·45	0·823	0·5073986	449	8	1416		499	37	0·5071577
138	3 13	32·814	7·65	17	29·25	0·45	0·822	0·5077365	449	8	1433		470	37	0·5074968
140	4 9	34·619	7·65	16	29·68	0·45	0·820	0·5073272	449	7	1454		497	37	0·5070828
													Mean	...	0·5072480
									Time of Vibration of Mean Pendulum					...	**0·5072504**
13-14 May, 1905.															
140	13 16	34·668	+7·47	17	26·35	−0·27	0·837	0·5073168	−438	−8	−1291	No correction applied	−507	−37	0·5070887
138	14 16	32·852	7·47	17	26·18	0·27	0·837	0·5077275	438	8	1283		479	37	0·5075030
139	15 11	34·335	7·47	17	25·90	0·27	0·838	0·5073890	438	8	1269		508	37	0·5071630
137	16 7	33·907	7·47	16	25·68	0·27	0·838	0·5074836	438	7	1258		498	37	0·5072598
													Mean	...	0·5072536
140	1 57	34·693	+7·47	17	27·02	+0·76	0·826	0·5073116	−438	−8	−1324		−501	−37	0·5070808
138	2 57	32·848	7·47	18	27·98	0·76	0·821	0·5077285	438	9	1371		470	37	0·5074960
139	3 55	34·304	7·47	17	28·79	0·76	0·820	0·5073956	438	8	1411		497	37	0·5071565
137	4 51	33·858	7·47	15	29·08	0·76	0·819	0·5074946	438	6	1425		486	37	0·5072554
													Mean	...	0·5072472
									Time of Vibration of Mean Pendulum					...	**0·5072504**

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
	14-15 May, 1905.														
	h m	s	s	′	°	°		s							s
139	13 25	34.373	+ 7.15	18	24.75	−0.19	0.845	0.5073806	− 420	−9	−1213	No correction applied	− 512	−37	0.5071615
137	14 19	33.940	7.15	16	24.60	0.19	0.842	0.5074760	420	7	1205		500	37	0.5072591
140	15 14	34.749	7.15	16	24.37	0.19	0.840	0.5072995	420	7	1194		509	37	0.5070828
138	16 12	32.907	7.15	17	24.27	0.19	0.840	0.5077143	420	8	1189		480	37	0.5075009
													Mean	...	0.5072511
139	1 49	34.394	+ 7.15	18	24.66	+0.57	0.833	0.5073760	− 420	−9	−1208		− 505	−37	0.5071581
137	2 47	33.947	7.15	16	25.00	0.57	0.834	0.5074747	420	7	1225		495	37	0.5072563
140	3 51	34.724	7.15	16	25.41	0.57	0.831	0.5073049	420	7	1245		504	37	0.5070836
138	4 53	32.882	7.15	17	26.62	0.57	0.824	0.5077205	420	8	1304		471	37	0.5074965
													Mean	...	0.5072486
								Time of Vibration of Mean Pendulum						...	**0.5072499**
	Dehra Dun—*(Pendulum Room).*														
	17-18 May, 1905.														
	h m	s	s	′	°	°		s							s
137	13 49	34.017	+ 0.04	17	26.87	−0.03	0.827	0.5074446	− 2	−8	−1316	− 1	− 491	−42	0.5072586
139	14 47	34.526	0.04	17	26.96	0.03	0.826	0.5073473	2	8	1321	1	501	42	0.5071598
138	15 44	33.031	0.04	17	26.91	0.03	0.827	0.5076850	2	8	1319	1	473	42	0.5075005
140	16 40	34.873	0.04	13	26.82	0.03	0.828	0.5072732	2	5	1314	1	502	42	0.5070866
													Mean	...	0.5072514
137	1 49	34.087	+ 0.04	14	26.85	+0.18	0.827	0.5074435	− 2	−5	−1316	+ 5	− 491	−42	0.5072584
139	2 49	34.528	0.04	15	27.07	0.18	0.825	0.5073468	2	6	1326	5	500	42	0.5071597
138	3 47	33.029	0.04	15	27.24	0.18	0.825	0.5076855	2	6	1335	5	472	42	0.5075003
140	4 42	34.866	0.04	14	27.37	0.18	0.825	0.5072747	2	5	1341	5	500	42	0.5070862
													Mean	...	0.5072512
								Time of Vibration of Mean Pendulum						...	**0.5072513**
	18-19 May, 1905.														
140	13 34	34.858	− 0.52	14	27.38	−0.05	0.826	0.5072763	+ 31	−5	−1342	− 1	− 501	−42	0.5070903
138	14 31	33.019	0.52	17	27.33	0.05	0.826	0.5076876	31	8	1339	1	472	42	0.5075045
139	15 28	34.511	0.52	16	27.33	0.05	0.826	0.5073506	31	7	1339	1	501	42	0.5071647
137	16 23	34.066	0.52	14	27.21	0.05	0.827	0.5074480	31	5	1333	1	491	42	0.5072639
													Mean	...	0.5072559
140	2 5	34.886	− 0.52	16	27.11	+0.16	0.826	0.5072705	+ 31	−7	−1328	+ 4	− 501	−42	0.5070862
138	3 0	33.071	0.52	17	27.29	0.16	0.825	0.5076753	31	8	1337	4	472	42	0.5074929
139	3 56	34.579	0.52	16	27.42	0.16	0.825	0.5073359	31	7	1344	4	500	42	0.5071501
137	4 56	34.121	0.52	15	27.57	0.16	0.822	0.5074360	31	6	1351	4	488	42	0.5072508
													Mean	...	0.5072450
								Time of Vibration of Mean Pendulum						...	**0.5072504**
	19-20 May, 1905.														
139	13 51	34.560	− 1.80	15	27.67	−0.20	0.826	0.5073400	+ 106	−6	−1356	− 5	− 501	−42	0.5071596
137	14 47	34.120	1.80	12	27.42	0.20	0.828	0.5074362	106	4	1344	5	492	42	0.5072581
140	15 42	34.914	1.80	14	27.18	0.20	0.829	0.5072646	106	5	1332	5	502	42	0.5070866
138	16 37	33.068	1.80	15	27.19	0.20	0.829	0.5076762	106	6	1332	5	474	42	0.5075009
													Mean	...	0.5072513
139	1 56	34.573	− 1.80	16	27.39	+0.19	0.826	0.5073371	+ 106	−7	−1342	+ 5	− 501	−42	0.5071590
137	2 52	34.119	1.80	13	27.65	0.19	0.824	0.5074363	106	4	1355	5	489	42	0.5072584
140	3 48	34.913	1.80	13	27.78	0.19	0.824	0.5072647	106	5	1361	5	499	42	0.5070851
138	4 44	33.056	1.80	15	27.93	0.19	0.824	0.5076790	106	6	1369	5	471	42	0.5075013
													Mean	...	0.5072509
								Time of Vibration of Mean Pendulum						...	**0.5072511**

TIME OF VIBRATION AT DEHRA DUN.

In the accompanying table the results of all the observations at Dehra Dún between November 1904 and May 1905 are collected, the times of vibration of each pendulum being shewn separately.

Table II. Times of Vibration at Dehra Dún.

Date	137	138	139	140	Mean
Pendulum room.					
November 1904.					
	s	s	s	s	s
Nov. 8—9	0·5072594	0·5075004	0·5071618	0·5070834	0·5072513
„ 9—10	2610	5024	1628	0853	2529
„ 10—11	2589	5020	1618	0851	2519
„ 11—12	2602	5017	1628	0856	2526
Mean	0·5072599	0·5075016	0·5071623	0·5070849	0·5072522
May 1905.					
May 17—18	0·5072585	0·5075004	0·5071598	0·5070864	0·5072513
„ 18—19	2574	4987	1574	0882	2504
„ 19—20	2583	5011	1593	0859	2511
Mean	0·5072581	0·5075001	0·5071588	0·5070868	0·5072509
Change May–Nov.	− 18	− 15	− 35	+ 19	− 13
Field station (*Tent*).					
November 1904.					
	s	s	s	s	s
Nov. 21—22	0·5072573	0·5074987	0·5071593	0·5070837	0·5072497
„ 22—23	2596	4996	1614	0835	2510
Mean	0·5072585	0·5074992	0·5071604	0·5070836	0·5072504
May 1905.					
May 12—13	0·5072571	0·5074995	0·5071600	0·5070849	0·5072504
„ 13—14	2576	4995	1598	0848	2504
„ 14—15	2577	4987	1598	0832	2499
Mean	0·5072575	0·5074992	0·5071599	0·5070843	0·5072502
Change May–Nov.	− 10	0	− 5	+ 7	− 2

The accordance between the values obtained in new pendulum room is by no means satisfactory and it appears possible that some change in the lengths of the pendulums may have taken place. The observations in the tent do not support this idea, but in an unsteady temperature, such as that met with in the tent, great reliance cannot be placed on the results.

To examine into the question of a possible change in the lengths of the pendulums, the differences between the time of vibration of each and the mean of the four have been taken out for each station, and tabulated. If there has been any change,—other than one in the same direction and of the same amount in all,—it will be revealed by a change in these differences.

Table III.—Differences between Individual Pendulums and Mean Pendulum.

Station	Date	137	v	138	v	139	v	140	v
Dehra Dun Pendulum Room	1904-05 Nov. 8-9	− 81	− 7	− 2491	+ 1	+ 895	− 11	+ 1679	+ 19
	„ 9-10	81	7	2495	− 3	901	5	1676	16
	„ 10-11	70	+ 4	2501	9	901	5	1668	8
	„ 11-12	76	− 2	2491	+ 1	898	8	1670	10
Dehra Dun Tent ...	Nov. 21-22	76	− 2	2490	+ 2	904	− 2	1660	0
	„ 22-23	86	12	2486	6	896	10	1675	+ 15
Cuttack	Dec. 12-13	78	− 4	2487	+ 5	904	− 2	1661	+ 1
	„ 13-14	74	0	2496	− 4	895	11	1677	17
	„ 14-15	73	+ 1	2491	+ 1	902	4	1663	3
	„ 16-17	75	− 1	2496	− 4	903	3	1668	8
Chatra ...	Dec. 30-31	74	0	2498	− 6	906	0	1667	+ 7
	„ 31-Jan. 1	69	+ 5	2503	11	908	+ 2	1666	6
	Jan. 1-2	68	6	2487	+ 5	889	− 17	1667	7
Kisnapur ...	Jan. 17-18	78	− 4	2494	− 2	904	− 2	1669	+ 9
	„ 18-19	72	+ 2	2496	4	908	+ 2	1662	2
	„ 19-20	70	4	2488	+ 4	900	− 6	1660	0
	„ 21-22	71	3	2495	− 3	906	0	1659	− 1
	„ 22-23	73	1	2495	3	910	+ 4	1659	1
Jalpaiguri ...	Jan. 31-Feb. 1	73	+ 1	2493	− 1	908	+ 2	1656	− 4
	Feb. 1-2	75	− 1	2493	1	911	5	1659	1
	„ 2-3	66	+ 8	2496	4	902	− 4	1660	0
Kesarbari ...	Feb. 14-15	78	− 4	2489	+ 3	912	+ 6	1655	− 5
	„ 15-16	78	4	2487	5	903	− 3	1663	+ 3
	„ 16-17	76	2	2497	− 5	922	+ 16	1652	− 8
	„ 17-18	78	4	2491	+ 1	909	3	1658	2
Ramchandpur ...	Feb. 25-26	77	− 3	2501	− 9	895	− 11	1684	+ 24
	„ 26-27	93	19	2497	5	941	+ 35	1650	− 10
	„ 27-28	77	3	2490	+ 2	900	− 6	1665	+ 5
Siliguri ...	Mar. 12-13	66	+ 8	2495	− 3	908	+ 2	1652	− 8
	„ 13-14	72	2	2495	3	912	6	1656	4
	„ 14-15	77	− 3	2492	0	909	3	1661	+ 1
	„ 15-16	67	+ 7	2512	20	919	13	1662	2
Darjeeling ...	Mar. 20-21	75	− 1	2482	+ 10	+ 900	− 6	1658	− 2
	„ 21-22	74	0	2491	1	903	3	1661	+ 1
	„ 22-23	71	+ 3	2494	− 2	908	+ 2	1658	− 2
Kurseong ...	Mar. 27-28	74	0	2470	+ 22	898	− 8	1644	− 16
	„ 28-29	76	− 2	2486	6	905	1	1655	5
	„ 29-30	67	+ 7	2489	3	905	1	1651	9
	„ 31-Ap. 1	73	1	2486	6	908	+ 2	1653	7
Sandakphu ...	Ap. 10-11	71	+ 3	2481	+ 11	899	− 7	1653	− 7
	„ 11-12	70	4	2491	1	905	1	1656	4
	„ 12-13	65	9	2485	7	902	4	1649	11
Dehra Dun Tent ...	May 12-13	67	+ 7	2491	+ 1	904	− 2	1655	− 5
	„ 13-14	72	2	2491	1	906	0	1656	4
	„ 14-15	78	− 4	2488	4	901	5	1667	+ 7
Dehra Dun Pendulum Room	May 17-18	72	+ 2	2491	+ 1	915	+ 9	1649	− 11
	„ 18-19	70	4	2483	9	930	24	1622	38
	„ 19-20	72	2	2500	− 8	918	12	1652	8
Mean ...	... ...	74	...	2492	...	906	...	1660	...

In the above table the columns with the heading v contain the residuals when the mean of all the differences appertaining to each pendulum is subtracted from the individual values. On the whole it does not appear that Nos. 137 and 138 have changed their lengths; there is, it is true, a long series of positive residuals, from about the middle of March onwards, in the case of both these pendulums, but the amounts are not large and may either be accidental, or the reflex effect of a more important change in one of the other pendulums. No. 139 has a series of negatives at the beginning and three large positives at the end: the latter are, I am inclined to think, accidental and, by increasing the mean, they have been to some extent the cause of the negatives. In the case of No. 140 there is certainly evidence of a progressive change. The unbroken series of positives at the beginning, then the belt of uncertain sign extending from about January 20th to March 20th, followed by the series of negatives, seem to indicate a gradual increase in the time of vibration. The change in the residuals from November to May seems to have been about 18 (the value −38 on May 18th–19th is I think due to an accidental error). This being the effect of the real change on the difference between the mean pendulum and No. 140, the real change must be

$$\frac{4}{3} \times 18 = 24.$$

If this were the only evidence it would be justifiable to infer that the length of this pendulum had been changing and to assign an increasing value to the time of vibration at Dehra Dun which is employed in the deduction of g at the other stations; but in view of the fact that the observations in the tent at Dehra Dun in November and May do not show any noteworthy change, it would be impossible without inconsistency to adopt such a course and I have therefore in this as in the case of all the other pendulums accepted a simple mean.

We have therefore the following:—

Table IV.—Times of Vibration at Dehra Dún to be used in deducing g.

	137	138	139	140	Mean
Pendulum Room	s 0·5072590	s 0·5075009	s 0·5071606	s 0·5070859	s 0·5072516
Tent	0·5072580	0·5074992	0·5071602	0·5070840	0·5072504

Table V shews the times of vibration of each pendulum at the different stations and the difference between these times and those at Dehra Dun.

At the stations of Cuttack, Kesarbari, Ramchandpur, and Siliguri comparison has been made both with the values obtained in the pendulum room and with those in the tent; at Chatra and Kisnapur with the tent-values only, and at the remaining stations with the room-values only.

Table V. Times of Vibration and differences from Dehra Ḍún.

Date	137	138	139	140	Mean
Cuttack.					
Applying lag correction					
1904	s	s	s	s	s
December 12-13	0·5073636	0·5076045	0·5072654	0·5071897	0·5073558
" 13-14	3618	6040	2649	1867	3544
" 14-15	3636	6054	2661	1900	3563
" 16-17	3637	6058	2659	1894	3562
Means	0·5073632	0·5076049	0·5072656	0·5071890	0·5073557
Dehra Pendulum Room	0·5072590	0·5075009	0·5071606	0·5070859	0·5072516
Difference	1042	1040	1050	1031	1041
Not applying lag correction					
Means	0·5073629	0·5076046	0·5072653	0·5071887	0·5073554
Dehra Tent	0·5072580	0·5074992	0·5071602	0·5070840	0·5072504
Difference	1049	1054	1051	1047	1050
Chatra.					
1904-05	s	s	s	s	s
December 30-31	0·5073047	0·5075471	0·5072067	0·5071306	0·5072973
" 31-Jan. 1	3060	5494	2083	1325	2991
January 1- 2	3052	5471	2095	1317	2984
Means	0·5073053	0·5075479	0·5072082	0·5071316	0·5072983
Dehra Tent	0·5072580	0·5074992	0·5071602	0·5070840	0·5072504
Difference	473	487	480	476	479
Kisnapur.					
1905	s	s	s	s	s
January 17-18	0·5072859	0·5075275	0·5071877	0·5071112	0·5072781
" 18-19	2847	5271	1867	1113	2775
" 19-20	2855	5273	1885	1125	2785
" 21-22	2833	5257	1856	1103	2762
" 22-23	2870	5292	1887	1138	2797
Means	0·5072853	0·5075274	0·5071874	0·5071118	0·5072780
Dehra Tent	0·5072580	0·5074992	0·5071602	0·5070840	0·5072504
Difference	273	282	272	278	276
Jalpaiguri.					
1905	s	s	s	s	s
January 31-Feb. 1	0·5072963	0·5075383	0·5071982	0·5071234	0·5072890
February 1-2	2955	5373	1969	1221	2880
" 2-3	2938	5368	1970	1212	2872
Means	0·5072952	0·5075375	0·5071974	0·5071222	0·5072881
Dehra Pendulum Room	0·5072590	0·5075009	0·5071606	0·5070859	0·5072516
Difference	362	366	368	363	365
Kesarbari.					
Applying lag correction					
1905	s	s	s	s	s
February 14-15	0·5072834	0·5075245	0·5071844	0·5071101	0·5072756
" 15-16	2868	5277	1887	1127	2790
" 16-17	2887	5308	1889	1159	2811
" 17-18	2919	5332	1932	1183	2841
Means	0·5072877	0·5075291	0·5071888	0·5071143	0·5072799
Dehra Pendulum Room	0·5072590	0·5075009	0·5071606	0·5070859	0·5072516
Difference	287	282	282	284	283
Not applying lag correction					
Means	0·5072872	0·5075286	0·5071883	0·5071138	0·5072794
Dehra Tent	0·5072580	0·5074992	0·5071602	0·5070840	0·5072504
Difference	292	294	281	298	290

Table V. Times of Vibration and differences from Dehra Dún—(Continued).

Date	137	138	139	140	Mean
Ramchandpur.					
Applying lag correction					
1905	s	s	s	s	s
February 25-26	0·5072846	0·5075270	0·5071874	0·5071085	0·5072769
„ 26-27	2827	5231	1793	1084	2734
„ 27-28	2846	5259	1869	1104	2769
Means	0·5072840	0·5075253	0·5071845	0·5071091	0·5072757
Dehra Pendulum Room	0·5072590	0·5075009	0·5071606	0·5070859	0·5072516
Difference	250	244	239	232	241
Not applying lag correction					
Means	0·5072837	0·5075250	0·5071842	0·5071088	0·5072754
Dehra Tent	0·5072580	0·5074992	0·5071602	0·5070840	0·5072504
Difference	257	258	240	248	250
Siliguri.					
Applying lag correction					
1905	s	s	s	s	s
March 12-13	0·5073029	0·5075458	0·5072055	0·5071311	0·5072963
„ 13-14	3042	5465	2058	1314	2970
„ 14-15	3058	5473	2072	1320	2981
„ 15-16	3027	5472	2041	1298	2960
Means	0·5073039	0·5075467	0·5072057	0·5071311	0·5072969
Dehra Pendulum Room	0·5072590	0·5075009	0·5071606	0·5070859	0·5072516
Difference	449	458	451	452	453
Not applying lag correction					
Means	0·5073035	0·5075463	0·5072052	0·5071307	0·5072964
Dehra Tent	0·5072580	0·5074992	0·5071602	0·5070840	0·5072504
Difference	455	471	450	467	460
Darjeeling.					
1905	s	s	s	s	s
March 20-21	0·5074049	0·5076456	0·5073074	0·5072316	0·5073974
„ 21-22	4045	6462	3068	2310	3971
„ 22-23	4045	6468	3066	2316	3974
Means	0·5074046	0·5076462	0·5073069	0·5072314	0·5073973
Dehra Pendulum Room	0·5072590	0·5075009	0·5071606	0·5070859	0·5072516
Difference	1456	1453	1463	1455	1457
Kurseong.					
1905	s	s	s	s	s
March 27-28	0·5073715	0·5076111	0·5072743	0·5071997	0·5073641
„ 28-29	3722	6132	2741	1991	3646
„ 29-30	3725	6147	2753	2007	3658
„ 31-Ap. 1	3719	6132	2738	1993	3646
Means	0·5073720	0·5076131	0·5072744	0·5071997	0·5073648
Dehra Pendulum Room	0·5072590	0·5075009	0·5071606	0·5070859	0·5072516
Difference	1130	1122	1138	1138	1132
Sandakphu.					
1905	s	s	s	s	s
April 10-11	0·5074847	0·5077257	0·5073877	0·5073123	0·5074776
„ 11-12	4849	7270	3874	3123	4779
„ 12-13	4843	7263	3876	3129	4778
Means	0·5074846	0·5077263	0·5073876	0·5073125	0·5074778
Dehra Pendulum Room	0·5072590	0·5075009	0·5071606	0·5070859	0·5072516
Difference	2256	2254	2270	2266	2262

The values of g derived from the differences in Table V are shewn in Table VI; g at Dehra Dún being taken to be 979·063.

Table VI. Deduced Values of g.

		137	138	139	140	Mean
Cuttack	(1) (2)	978·661 ·658	978·661 ·656	978·658 ·657	978·665 ·659	978·661 ·658
Chatra	...	978·880	978·875	978·878	978·879	978·878
Kisnapur	...	978·958	978·954	978·958	978·956	978·956
Jalpaiguri	...	978·924	978·922	978·921	978·923	978·922
Kesarbari	(1) (2)	978·952 ·951	978·954 ·950	978·954 ·955	978·953 ·948	978·953 ·951
Ramchandpur	(1) (2)	978·967 ·964	978·969 ·963	978·971 ·970	978·973 ·967	978·970 ·966
Siliguri	(1) (2)	978·890 ·887	978·886 ·881	978·889 ·889	978·888 ·883	978·888 ·885
Darjeeling	...	978·501	978·502	978·498	978·501	978·501
Kurseong	...	978·626	978·630	978·624	978·624	978·626
Sandakphu	...	978·192	978·193	978·187	978·188	978·190

Reduction to Sea-level.

The computation of the orographical correction was carried out in the same way as before, but the regions surrounding the stations were not analysed so minutely.

The Nepal frontier lies but a short distance to the west of the hill stations visited this year, and as there are no trustworthy maps of that country a detailed examination would have been unprofitable.

The stations which came under consideration were Jalpaiguri, Siliguri, Kurseong, Darjeeling and Sandakphu; I was in doubt as to whether a correction would be required at Jalpaiguri. The distance of this place from the foot hills is about 28 miles, that of Siliguri is about 8 miles; I decided to compute the corrections for the latter first and so obtain some idea of the magnitude of the attraction exercised by the hills on places not far from their foot.

In the tables that follow I have not thought it necessary to give so much detail as was done in the case of Mussooree.

Toble VII. Orographical corrections at Siliguri.

Height 387 feet.

r_1 r_2	$7\frac{1}{2}$ miles 10 „	10 miles $12\frac{1}{2}$ „	$12\frac{1}{2}$ miles 15 „	15 miles 20 „	20 miles 25 „	25 miles 30 „	30 miles 35 „
Azimuth from N	Δh	Δh	Δh	Δh	Δh	Δh	Δh
	feet	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*
0-15	100	1100	1600	1600	1600	2600	3600
15-30	100	200	400	2100	3600	3600	3600
30-45	0	100	200	1600	1600	2100	5600
45-60	0	0	100	300	400	600	1100
60-75	0	0	0	100	100	100	200
75-90	0	0	0	0	0	0	0
90-270	Southern	Compartme	nts all at the	same level	as the sta	tion	
270-285	0	0	0	400	600	600	1600
285-300	0	100	300	1100	2600	3600	3600
300-315	100	200	1100	2600	3600	2600	4600
315-330	200	600	2600	2600	3600	4600	6600
330-345	300	1600	2600	4600	5600	3600	4600
345-360	300	2100	2600	2600	2600	2100	3600
Effect ...	0·03	0·68	1·26	3·51	3·54	2·29	2·73

Total effect of zones within 35 miles radius = 14·04

Attraction .... = 14·04 × 0·000035

= 0·00049

From this result it may be inferred that at Jalpaiguri the effect of the hills up to a radius of 35 miles will be entirely negligible.

Not far beyond the 35 miles radius in the case of Siliguri, and of a 60-mile radius in the case of Jalpaiguri, lie the giant mountains of the Kinchinjunga group, and beyond that again are the highlands of Tibet. We may take account of them by assuming that in the case of Siliguri one-third of the region outside the 35-mile circle is occupied by a table-land 7000 feet high, and that the same is true of Jalpaiguri outside the 60-mile radius. 7000 feet is undoubtedly too low for the Tibetan plateau, 12000 feet would be nearer the truth, but for the Himalayan region, where deep valleys alternate with high peaks, 7000 feet is probably a sufficient estimate even among the high ranges, and among the outer hills it is too great, so that on the whole, considering the greater proximity of the smaller ranges, this average height may be accepted.

The attraction of this outer region at Siliguri is found by formula (2) to be 0·0015.

So that the total orographical correction is—

$$0 \cdot 0015 + 0 \cdot 0005$$
$$= 0 \cdot 0020.$$

At Jalpaiguri the attraction of the outer region is—

$$0 \cdot 0009.$$

Hence an orographical correction of 0·001 may be applied.

Table VIII. Orographical Correction at Kurseong.

Height 4913 feet.

Zones up to 3 miles.

No. of Zone	Inner Radius	Outer Radius	Δh				Effect
	feet	*feet*					
1	50	100	0	5	10	20	0·5
2	100	200	20	20	40	45	2·8
3	200	400	30	40	75	90	4·8
4	400	600	55	65	130	150	4·3
5	600	1000	90	100	210	240	9·5
6	1000	2000	93	230	363	577	29·8
7	2000	3000	155	370	547	743	19·8
8	3000	4000	177	420	690	1077	17·8
9	4000	5280	292	612	983	1448	25·5
10	5280	7920	333	890	1337	1852	46·3
11	7920	10560	520	1237	1702	2243	37·3
12	10560	13200	620	1573	2077	2660	30·3
13	13200	15840	690	1690	2560	3060	29·8
						Sum ...	258·5

Table IX. Orographical Correction at Kurseong.

Height 4913 feet.

Zones from 3 to 35 miles.

No. of Zone	14	15	16	17	18	19	20	21	22	23	24
r_1 r_2	3 miles 4 "	4 miles 5 "	5 miles 6 "	6 miles 7½ "	7½ miles 10 "	10 miles 12 "	12 miles 16 "	16 miles 20 "	20 miles 25 "	25 miles 30 "	30 miles 35 "
	Δh	Δh	Δh	Δh	Δh	Δh	Δh	Δh	Δh	Δh	Δh
	feet	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*
	400	900	2200	2600	2200	900	1700	2400	400	1600	2100
	900	2100	1800	1400	900	600	1700	2400	900	1600	1600
	1500	1300	600	700	1500	2900	3400	2900	2400	900	600
	600	500	600	2200	2600	3400	3400	2400	1200	1100	1300
	1600	900	900	900	1400	2900	1900	1600	1400	1400	1600
	2500	2600	2800	2100	2600	2900	3400	2400	2900	3400	3400
	2600	3600	3600	3200	3100	3900	4100	4100	4100	4100	4100
	2700	3200	3400	3700	3700	3900	4300	4500	4300	4400	4500
	2000	2900	3500	4000	4400	4400	4500	4600	4500	4600	4600
	2800	3500	3800	4200	4400	4500	4600	4600	4600	4600	4600
	3500	3700	4100	4200	4500	4500	4600	4600	4600	4600	4600
	3500	3900	4100	4400	4500	4500	4600	4600	4600	4600	4600
	3300	3700	4000	4400	4500	4500	4600	4600	4600	4600	4600
	3000	3800	3700	4000	4400	4500	4600	4600	4600	4600	4600
	3200	3300	3300	3500	4300	4500	4500	4600	4600	4600	4600
	2900	2100	2100	2700	3600	3900	4100	4600	4600	4500	4500
	2500	1700	1100	2400	2700	2900	3400	3900	3900	3900	3400
	2400	1200	700	1400	900	2400	1900	2900	2400	3400	2400
	1900	700	300	200	600	1900	1900	1900	900	1900	1400
	2200	1900	1400	900	400	100	900	100	100	1100	100
	2200	1600	1100	400	300	1100	100	2600	3100	3100	100
	1500	1600	1700	1200	600	1100	2000	2100	4100	4100	2100
	900	300	700	600	1400	900	1400	1100	2100	2600	4100
	300	300	800	1100	2100	900	1700	2400	1100	1600	2100
Effect ...	42·6	28·6	20·4	23·5	28·5	16·5	24·6	14·7	10·9	8·1	4·3

Total effect of zones within 35 miles radius = 481·2

Attraction ... ... = 481·2 × 0·000035

= 0·0168

For the country lying outside the 35-mile radius we may, at Kurseong, make the same assumption as was made for Mussooree, namely, that the southern half is at sea-level and that the northern half consists of an elevated plain. In the case of Mussooree I assumed this plain to be at the same height as the station, here I shall assume it to be 2,000 feet higher than the station. Thus to complete the orographical correction we require the effect of half the infinite plain outside the 35-mile radius + the effect of a half zone 2,000 feet thick of which the inner radius is 35 miles and the outer infinite.

Attraction of infinite plain = 0·1720
„ „ plain of 35-mile radius = 0·1696

Difference = 0·0024
Half difference = 0·0012

Attraction of half zone 2000 feet thick = 0·00019
Quantity required to complete orographical correction = 0·0014
Total orographical correction = 0·0168 + 0·0014
= 0·0182

Table X. Orographical Correction at Darjeeling.

Height 6966 *feet.*

(Zones up to 6 *miles).*

No. of Zone	Inner Radius	Outer Radius	Δh				Effect
	feet	*feet*	*feet*	*feet*	*feet*	*feet*	
1	100	200	10	23	34	49	2·5
2	200	300	21	41	53	76	2·0
3	300	500	23	60	92	131	4·5
4	500	700	31	77	141	211	5·0
5	700	1000	44	71	133	248	4·5
6	1000	1300	49	124	220	343	5·0
7	1300	1600	86	239	343	484	7·0
8	1600	2040	112	337	470	650	12·3
9	2040	2640	164	499	664	851	18·5
10	2640	3300	194	621	966	1241	24·5
11	3300	3960	324	749	1141	1499	24·8
12	3960	5280	327	974	1333	1549	38·3
13	5280	6600	394	1166	1574	2016	36·0
14	6600	7920	416	1266	1833	2466	33·3
15	7920	10560	849	1649	2149	2849	60·5
16	10560	13200	877	1916	2533	3233	48·0
17	13200	15840	322	1683	2833	3599	36·8
18	15840	21120	528	1599	3566	4316	65·3
19	21120	26400	650	1749	3749	4999	49·0
20	26400	31680	922	2183	3533	5516	37·3
						Sum ...	515·1

Table XI. Orographical Correction at Darjeeling.

Height 6966 *feet.*

(Zones from 6 *to* 35 *miles).*

No. of Zone	21	22	23	24	25	26	27	28
r_1 r_2	6 miles 7½ "	7½ miles 10 "	10 miles 12½ "	12½ miles 15 "	15 miles 20 "	20 miles 25 "	25 miles 30 "	30 miles 35 "
	Δh	Δh	Δh	Δh	Δh	Δh	Δh	Δh
	feet	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*
	5000	2500	1500	2000	2000	1500	2000	6000
	4500	1800	1500	700	500	1200	2000	5000
	4500	2500	1000	700	2000	1500	1000	1000
	5500	5000	3000	2500	3500	1000	500	2000
	5200	5500	4500	5000	5000	3000	2500	1500
	2500	5000	5500	4000	3000	2000	3000	1500
	2700	5500	5000	5800	3500	4500	4500	5000
	4100	5500	6000	5500	4000	5500	6300	6400
	3500	4500	5000	5800	6000	6500	6600	6700
	1700	3000	3500	4000	6300	6600	6700	6700
	800	1500	4000	5000	6500	6600	6700	6700
	1000	2500	2000	4500	6300	6600	6700	6700
	1900	3500	3500	4500	5500	6600	6700	6700
	3300	3000	3000	4000	5500	6200	6700	6700
	3200	2000	3000	4000	5000	5500	6600	6500
	1700	1000	2000	3000	3000	4000	5500	6000
	900	1000	2000	2000	3000	3000	4500	5000
	2700	2000	1500	1500	1000	1000	1000	2000
	2500	800	1500	1500	2000	1000	1000	3000
	2700	1000	1000	1500	2500	1000	1000	1000
	2700	2000	2000	1000	2500	2000	1000	1000
	3800	2500	1800	1500	2000	2500	2000	4000
	4500	1800	1000	1000	2000	2000	4000	5000
	4000	1500	1000	500	800	1000	4000	6000
Effect	36·1	32·6	18·6	14·7	24·8	15·7	13·4	9·5

Total effect of zones within 35-mile radius = 680·5

Attraction = 680·5 × 0·000035 = 0·0238

At Darjeeling the assumption that was made for Mussooree and Kurseong, is not applicable; for this station lies further in among the hills. But the effect of the zones beyond the 35-mile radius may be estimated in another way. As we extend the radii, the character of the compartments of which the zones are composed will not change much; the southern halves of the zones will lie almost wholly in the plains, the northern compartments among the higher ranges and the eastern and western among the outer hills, thus there will be no great change in the effect of the zones because of changes in the heights of their compartments, and there will be a continual decrease owing to the increasing distance from the station. This decrease is proportional to the decrease in the difference between the reciprocals of the radii. If we make this difference constant and equal to its value for the 30-35- mile zone, we find the following radii 42, 53, 70, 105, 210, 100000, we may therefore take it that the masses which lie beyond the 35-mile radius will have an effect equivalent to six times that of the 30-35-mile zone. The effect of this zone was 9·5, so that 57·0 is to be added for the outer regions. The addition to the orographical correction is therefore

$$57{\cdot}0 \times 0{\cdot}000035 = 0{\cdot}0020$$

and the total correction is

$$0{\cdot}0238 + 0{\cdot}0020 = 0{\cdot}0258$$

Table XII. Orographical Correction at Sandakphu.

Height 11766 *feet.*

(Zones up to 4 miles).

No. of Zone	Inner Radius	Outer Radius	Δ*h*				Effect
	feet	*feet*	*feet*	*feet*	*feet*	*feet*	
1	200	300	6	9	27	54	0·8
2	300	400	9	14	34	52	0·4
3	400	500	13	18	24	67	0·3
4	500	1000	55	149	233	433	27·0
5	1000	1500	233	333	583	866	41·8
6	1500	2000	283	549	899	1166	42·5
7	2000	2640	416	633	983	1433	45·5
8	2640	3300	483	791	1091	1624	38·5
9	3300	3960	508	941	1358	1799	35·0
10	3960	5280	716	1208	1733	2216	69·5
11	5280	7920	816	1716	2133	2866	116·8
12	7920	10560	1049	2016	2533	3466	86·5
13	10560	15840	1499	2566	3166	3933	128·5
14	15840	21120	2199	3033	3466	4166	83·3
						Sum ...	716·4

Table XIII. Orographical Correction at Sandakphu.

Height 11766 *feet.*

(Zones from 4 to 35 miles).

No. of Zone	15	16	17	18	19	20	21	22	23	24
r_1 r_2	4 miles 5 „	5 miles 6 „	6 miles $7\frac{1}{2}$ „	$7\frac{1}{2}$ miles 10 „	10 miles 12 „	12 miles 16 „	16 miles 20 „	20 miles 25 „	25 miles 30 „	30 miles 35 „
	Δh	Δh	Δh	Δh	Δh	Δh	Δh	Δh	Δh	Δh
	feet	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*	*feet*
N	1000	1300	1000	800	1800	2800	1800	1200	3200	5200
	600	1400	2000	2800	3800	3800	2800	1800	700	2200
	2100	2100	3000	2300	4800	3800	5800	4800	2800	2200
	3100	3700	4800	2800	3800	4800	5800	6800	4800	1800
	5000	5400	5800	4800	5800	8800	7800	6800	5800	6800
E	3200	4400	6000	6800	7800	8800	8800	8800	7800	8800
	4000	5600	6300	6300	6800	7800	6800	9300	9800	9800
	5200	6000	4600	5300	7800	5800	5800	5800	8800	10300
	4800	3900	3100	5100	6800	5800	7800	6800	9300	11100
	3700	3300	2400	4300	5800	5800	7800	8800	10800	11400
	2900	2800	3800	4800	6800	6800	8800	10800	11200	11500
S	4300	3800	4300	5800	7800	7800	9800	10600	11500	11500
	No map available for the western halves of these zones. It has been assumed that they are the same as the eastern halves.		5800	6800	8800	8800	9800	10300	11400	11500
			6800	5800	8800	9800	9800	10800	10800	10800
			5800	6800	8800	8800	9300	9800	10300	10800
			5800	6800	7800	6800	8800	7800	7800	8800
			6800	4800	6800	5800	7800	6800	7800	7800
W			4800	3800	6800	6800	7800	8800	8800	9800
			5800	5800	6800	7800	8800	8800	7800	5800
			4800	4800	5800	7800	8800	7800	7800	4800
			5800	5800	5800	5800	7800	6800	7800	6800
			5800	5800	5800	4800	7800	6800	5800	3800
			4800	4800	3800	5800	5800	5800	2800	6800
N			2800	2800	3800	6800	5800	6800	4800	5800
Effect	62·1	48·4	76·4	83·8	67·5	88·3	72·5	58·6	43·4	26·5

Total effect of zones within 35-mile radius = 1343·9

Attraction = 1343·9 × 0·000035 = 0·0470

At Sandakphu the outer zones may be treated in the same way as at Darjeeling.

The effect of the 30-35-mile zone was 26·5, hence that of the remainder may be estimated at 26·5 × 6 = 159·0, and the addition to the orographical correction is

$$159{\cdot}0 \times 0{\cdot}000035 = 0{\cdot}0056$$

$$\text{The total correction therefore} = 0{\cdot}0470 + {\cdot}0056 = 0{\cdot}0526$$

The results of the season's work are summarised in Table XIV. In the case of stations at which the times of vibration are given in Table V both with and without a lag correction, the mean of the two values at Dehra Dún, that is to say in the room and in the tent respectively, and the mean of the differences, have been used in computing g. The formula employed was

$$g = g_0 - 2g_0 \frac{s - s_0}{s_0} + 3g_0 \left(\frac{s - s_0}{s_0}\right)^2$$

where the letters with the subscript 'o' refer to Dehra Dún.

The third term of the formula has not been used except in the case of Sandakphu.

When $s - s_0 = 2090 \times 10^{-7}$, the value of this term = 0·0005.

For g_0 the same value as before, namely 979·063 has been adopted.

Table XIV. Abstract of final Results.

Station	Latitude	Height	Observed g	$g\frac{2h}{R}$	$g\frac{3}{4}\frac{h}{R}$	O	Value at sea level g_0''	γ_0	$g_0'' - \gamma_0$
	° ′	feet							
Cuttack ...	20 29	92	978·659	+0·009	−0·003	0·000	978·665	978·636	+0·029
Chatra ...	24 13	64	978·878	+0·006	−0·002	0·000	978·882	978·873	+0·009
Kisnapur ...	25 2	113	978·956	+0·011	−0·004	0·000	978·963	978·930	+0·033
Ramchandpur ...	25 41	132	978·968	+0·013	−0·005	0·000	978·976	978·975	+0·001
Kesarbari ...	26 8	204	978·952	+0·019	−0·007	0·000	978·964	979·007	−0·043
Jalpaiguri ...	26 31	268	978·922	+0·025	−0·009	+0·001	978·939	979·035	−0·096
Siliguri ...	26 42	387	978·887	+0·036	−0·014	+0·002	978·911	979·048	−0·137
Kurseong ...	26 53	4913	978·626	+0·460	−0·172	+0·018	978·932	979·062	−0·130
Darjeeling ...	27 3	6966	978·501	+0·646	−0·242	+0·026	978·931	979·074	−0·143
Sandakphu ...	27 6	11766	978·190	+1·096	−0·411	+0·053	978·928	979·078	−0·150

Professor Dr. Hecker has been so kind as to furnish me with the full details of his observations at Jalpaiguri, but as they will appear in the publications of the Prussian Geodetic Institute it will be sufficient for me to give a summary of them here. He was equipped with a set of six pendulums namely Nos. 5, 6, 7, 8, 16 and 21, but No. 6 has not been utilised in the determination of g*.

The times of vibration of the 5 pendulums at Potsdam before and after his journey were:—

Pendulum	5	7	8	16	21	Mean
	s	s	s	s	s	s
Before ...	0·5083411	0·5083150	0·5083166	0·5076739	0·5097473	0·5084788
After ...	0·5083413	0·5083138	0·5083143	0·5076740	0·5097472	0·5084781
Mean ...	0·5083412	0·5083144	0·5083155	0·5076740	0·5097473	0·5084785

At Jalpaiguri Dr. Hecker observed each pendulum six times obtaining the following values:—

Pendulum	5	7	8	16	21	Mean
	s	s	s	s	s	s
	0·5089497	0·5089250	0·5089278	0·5082828	0·5103598	0·5090890
	519	241	264	830	613	93
	494	244	242	820	587	77
	501	240	246	821	590	80
	512	229	239	827	596	81
	504	233	244	826	591	80
Mean ...	0·5089505	0·5089240	0·5089252	0·5082825	0·5103596	0·5090884
Difference from Potsdam	6093	6096	6097	6085	6123	6099

The resulting values of g at Jalpaiguri are:—

Pendulum	5	7	8	16	21
g	978·926	978·925	978·924	978·926	978·921
Mean 978·924					

My value (vide table XIV) is 978·922 and the agreement between the two results is extremely satisfactory.

My value of g at Jalpaiguri is obtained by three steps namely:—

g at Potsdam ... = 981·274

1. g at Kew less than g at Potsdam by 0·074

(Mr. Putnam's determination in 1900) = 981·200

* I am not aware of the reason for omitting the result by No. 6.

2. g at Dehra Dún less than g at Kew by 2·137

(observations of 1903-04) = 979·063

3. g at Jalpaiguri less than g at Dehra by 0·141

(observations of 1904-05) = 978·922

The agreement therefore of Dr. Hecker's result with mine makes it probable that there is no error of importance in any of the above steps. This is the more satisfactory as the Dehra Dún observations of 1904-05 were not by any means as accordant as could be wished.

It is still desirable that the connection between Kew and Dehra be strengthened when an opportunity occurs, but in the mean time we may feel tolerably confident that the value 979·063 which has been adopted for Dehra Dún is not far from the truth.

CHAPTER IV.

The Observations in 1905-06.

For the scene of the operations in 1905-06 Colonel Burrard selected a line running, roughly speaking, from Simla to Quetta. The objects in view were:—

(1) To ascertain whether the marked deficiencies in the force of gravity, which had been observed in the outer Himalayan Range, and in the submontane tracts, both on the meridian of Dehra Dún and on that of Darjeeling, would again be found in the neighbourhood of Simla.

(2) To see whether the pendulums would throw light on the deflections of the Plumb-line indicated by the Amritsar—Multán arc of longitude. On this arc one would have expected to find the Plumb-lines at both ends deflected outwards, towards the Himalayas and the Suleman mountains respectively, but it was found on the contrary that they were deflected inwards.

(3) To make a first step towards the examination of the Baluchistan mountains.

(4) To make a set of observations at Captain Basevi's station at Mián Mir. This was the last station at which Basevi observed before starting on his journey to Moré, and at it the pendulums were swung on a stand which had been specially constructed for that difficult expedition. It has been thought that this stand may have been less rigid than the ordinary one, and that therefore the observations at Mián Mir and Moré may require a specially large correction for flexure.

The observations of the previous season had shewn that the variations of temperature in a tent are too large; it was decided therefore to visit during this season only places in which suitable houses were available. Through the kind assistance of the officers of the P. W. Department, of the Indian Civil Service and the Military Works Service, good observing rooms were obtained at all the stations visited.

The equipment was the same as before except that the Transit Instrument No. 1 was used instead of No. 2. No. 1 had been fitted with a glass diaphragm with lines ruled upon it instead of the spider webs hitherto employed. There had been a good deal of trouble with the webs owing to their breaking or becoming loose, and I therefore determined to try lines on glass. The diaphragm was made and fitted by Messrs. Troughton and Simms. It is certainly very much more convenient than the webs and I donot think that there has been any falling off in the accuracy of the intersections.

An improvement was introduced this year in the method of observing the star-transits. Hitherto it has been the custom to divide the programme of stars into two parts and to observe the one in the position I. P. E.* and the other in the position I. P. W. This year the plan was adopted of reversing the telescope in the middle of the observation of each star, this cancels collimation error, error due to inequality of pivots and error due to imperfect knowledge of the

* Illuminated pivot east.

wire-intervals. Furthermore the reduction of the observations is much abbreviated, for the process of reducing to the centre wire is got rid of, without losing the check on the accuracy of the intersections afforded by a comparison of the times of transit over each wire.

Throughout the season the time observations were undertaken by Babu Hanuman Prasad.

The same set of thermometers was used this year as last. During the summer three of them, namely Nos. 105368 and 105369 by Negretti and Zambra and No. 516 by Fuess had been sent to the National Physical Laboratory for a redetermination of their errors. The results agreed well with those of the determination made in Nov. 1903.

A dummy pendulum, with a hollow stem for the reception of a thermometer, was also made for me during the summer by the Mathematical Instrument Department.

A dummy pendulum for the thermometers intended to give the temperature of the true pendulum was included in the equipment used by Captain Basevi*, and so far as I am aware, one has always formed part of the Von Sterneck apparatus. A device of this kind is specially necessary when the temperature is unsteady, and I regretted that I was not equipped with one when observing in the tent. Dr. Hecker had one with him and the one made for me is a copy of his.

I took the dummy pendulum into use at Dehra Dún at the beginning of the field season, and the results it gave seemed quite satisfactory, but after that I found that whether the temperature of the air was rising or falling the reading of the thermometer in the dummy was always considerably below that of the other thermometers; the reason I at last found to be that there was too much connection between the dummy and the masonry pillar. The latter at all the stations except Dehra Dún had been but recently built, and was damp and colder than the surrounding air, and the dummy was constantly parting with its heat to the stone cap through the little tripod on which it stood. I could not alter the state of things during the tour and I therefore used the readings of the two thermometers attached to the stand for the reduction of the observations, as on former occasions.

The masonry pillar for the pendulum stand was of the same pattern and dimensions as before.

The temperature conditions were fairly satisfactory at all the stations visited, and as there was but little difference between them and those that obtained at Dehra Dún, no lag corrections have been applied. The rate of change of the temperature is shewn in the table giving the details of the observations, whence it may be seen that the corrections if computed would have been of nearly equal magnitude throughout, and therefore without effect on the differences from Dehra Dún.

The latitudes and longitudes have all been taken off the 1-inch or 2-inch map, whichever was available, except in one or two cases which are mentioned in the descriptions of the stations. The way in which the height of each station was derived is also mentioned in the description.

The longitudes have all received the correction necessary to reduce them to the most recent terms, namely those in which the longitude of Madras has the value 80° 14′ 54″.

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* *Vide* Vol. V *Op. G. T. S.* Chapter II, Para 5.

THE STATIONS.

Dehra Dun.

	°	′	″
Latitude	30	19	29
Longitude	78	3	22
Height above mean sea level ...	2241 feet		

The observations were made in the new pendulum room. None were taken in the tent.

The flexure correction was observed four times:—

12th November	15th November
$42^{s}.5 \times 10^{-7}$	$42^{s}.9 \times 10^{-7}$
42·5	42·3

Adopted Correction $-43^{s} \times 10^{-7}$

Simla.

	°	′	″
Latitude	31	6	19
Longitude	77	9	50
Height above mean sea level ...	7043 feet		

The pendulum station was situated in one of the rooms on the N. W. side of the civil secretariat (Gorton Castle). The height was determined by levelling from the P. W. D. h. s. of the Simla triangulation.

The floor of the room was good and an isolated foundation for the pendulum pedestal was not provided.

The temperature conditions were good. The observations were much delayed by cloudy weather; the apparatus was ready on the 12th December but no stars were obtained till the 15th.

The flexure correction was determined five times, but only the last three observations have been used as the other two were made on the 12th.

The results were:—

14th December	19th December
$34^{s}.7 \times 10^{-7}$	$35^{s}.1 \times 10^{-7}$
	34·4

Adopted Correction $-35^{s} \times 10^{-7}$

Kalka.

	°	′	″
Latitude	30	50	8
Longitude	76	56	22
Height above mean sea level ...	2202 feet		

The pendulum station was situated in the last room but one from the east end of the long single-storied building known as Lowrie's hotel.

To ascertain the height a line of levels was run from rail-level at the railway station to the floor of the room, showing that the latter is 55 feet higher than the former. Rail-level at

Kálka is 1251 feet above rail-level at Ambála, and rail-level at Ambála was found, by running a line to the G. T. bench-mark on the steps of the church, to be 896 feet above mean sea level.

Only one set of observations was made at this station.

The flexure correction was determined four times:—

22nd December	23rd December
$41^{s}\cdot5 \times 10^{-7}$	$40^{s}\cdot8 \times 10^{-7}$
40·2	43·4

Adopted Correction $-42^{s} \times 10^{-7}$

Ludhiana.

	°	′	″
Latitude	30	55	25
Longitude	75	51	9
Height above mean sea level ...	835 feet.		

The pendulum station was situated in the western room of the ground floor of the two-storied block of officers' quarters in Ludhiána fort. The room has thick walls and a vaulted roof, and the temperature conditions were good. Isolated platforms were built for the pendulum pedestal and for the clock.

The height was determined by running a line of levels from the centre of the metalling at the junction of the Ambála and Ferozepore roads. It was assumed that this point was 2 feet higher than the imbedded bench-mark of the G. T. levels mentioned on p. 107 of the pamphlet of 1863. This bench-mark could not be found.

The flexure correction was determined five times:—

30th December	5th January
$43^{s}\cdot5 \times 10^{-7}$	$43^{s}\cdot6 \times 10^{-7}$
43·8	40·7
	41·4

Adopted Correction $-43^{s} \times 10^{-7}$

At this station the method of reversing the transit instrument in the middle of the observation of each star, was used for the first time.

Mian Mir.

	°	′	″
Latitude	31	31	37
Longitude	74	22	32
Height above mean sea level ...	708 feet.		

The pendulum station was situated in the southernmost of the three principal rooms of a small bungalow which stands immediately behind (*i. e.* to the west of) Messrs. Jamsetjee's shop, and a little to the east of north of the racket court.

This is probably not the same house as that in which Captain Basevi observed in 1871. Enquiries from old residents shewed that there had been a small house about 100 yards further west, which had been pulled down some time ago, it seems probable that it was there that the old pendulum observations were made.

The height was determined by a line of levels from a G. T. bench-mark on the steps of the church.

The longitude given by Captain Basevi for his station is 74° 25′ 40″, that which I found for my station by a traverse to the church, the co-ordinates of the steeple of which are given in Synoptical Volume IV of the G. T. Survey, was 74° 24′ 59″ (in the old terms). Taking into consideration the distance of about 100 yards that separated the two stations and the fact that Captain Basevi's was to the west of mine, the longitude of the old pendulum station, as deduced from that of mine, must have been 74° 24′ 56″ approximately. I am unable to explain the difference of 44″ between Captain Basevi's value and that now deduced. It would appear that his value is not in terms of the datum of the G. T. Survey, *viz.*, Warren's value for the Longitude of Madras, 80° 17′ 21″. It is not, however, to be supposed that this discrepancy indicates a doubt as to the identification of Basevi's station. It was ascertained with complete certainty that his station was situated somewhere within a certain acre of ground.

The floor of the room was not good and isolated platforms were built both for the pendulums and for the clock.

The flexure correction was determined five times:—

	9th January	13th January
	s	s
	$40 \cdot 3 \times 10^{-7}$	$36 \cdot 1 \times 10^{-7}$
	$42 \cdot 3$	$37 \cdot 6$
	$39 \cdot 1$	...
Adopted Correction	s $- 39 \times 10^{-7}$	

Ferozepore.

		°	′	″
Latitude	... ...	30	55	48
Longitude	... ...	74	37	4
Height above mean sea level ...			647 feet.	

The pendulum station was situated in the eastern room of the P. W. D. Rest-house, the latter stands about 570 yards east of the junction of the main road to Lahore with the Ferozepore Mall.

The height was determined by a line of levels run from a bench-mark of the G. T. Survey on the 1st mile-stone on the Lahore road.

The floor of the room was good and isolated platforms were not provided.

The flexure correction was determined six times:—

17th January	19th January	21st January
s	s	s
$51 \cdot 2 \times 10^{-7}$	$47 \cdot 1 \times 10^{-7}$	$48 \cdot 7 \times 10^{-7}$
$51 \cdot 8$	$48 \cdot 9$	$48 \cdot 4$

For the first two sets of observations the value $-\overset{s}{50} \times 10^{-7}$ was adopted and for the last set the value $-48^{s} \times 10^{-7}$.

Pathankot.

		°	′	″
Latitude	... ...	32	16	33
Longitude	... ...	75	39	3
Height above mean sea level ...			1088 feet	

The pendulum station was situated in the room at the east side of the District Rest-house. This room is about 710 feet north, and 565 feet east of the centre of the platform of the railway station.

A line of levels was run from the railway to the pendulum room showing that the latter is 4·6 feet above rail-level. The height of the rails given by the railway authorities was 1083·7 feet.

The flexure correction was determined four times:—

31st January	5th February
s	s
$39 \cdot 8 \times 10^{-7}$	$38 \cdot 5 \times 10^{-7}$
40·9	39·8

Adopted Correction $- \overset{s}{40} \times 10^{-7}$

Montgomery.

		°	′	″
Latitude	... ...	30	39	47
Longitude	... ...	73	6	18
Height above mean sea level ...			557 feet	

The pendulum station was in the Municipal Building, it was about 530 feet south and 2900 feet east of the monument to L. O. Fitzhardinge Berkeley which stands immediately in front of the cutcherry.

The height of the floor of the room was determined by levelling from the railway station.

The flexure correction was determined seven times:—

11th February	14th February	16th February	20th February
s	s	s	s
$41 \cdot 8 \times 10^{-7}$	$40 \cdot 0 \times 10^{-7}$	$40 \cdot 9 \times 10^{-7}$	39.6×10^{-7}
41·8	41·4	...	40·3

Adopted Correction $- \overset{s}{41} \times 10^{-7}$

Dera Ghazi Khan.

		°	′	″
Latitude	... ...	30	3	49
Longitude	... ...	70	45	38
Height above mean sea level ...			397 feet	

The pendulum station was situated in a house on the eastern side of the road which runs nearly north and south and passes between the Church and the Cutcherry. The pillar was about 1400 feet south and 430 feet west of the centre of the Church.

There had been an imbedded bench-mark of the principal levelling close to the gate of the Treasury, but it could not be found; so it was assumed that it had been 1 foot below ground level, and a line of levels was run from its probable position to the pendulum room.

The flexure correction was determined four times, and showed that a large change in the rigidity of the pillar took place while the observations were in progress, this was due to the cement being still wet when the observations began, and becoming harder gradually.

The results of the observations were:—

27th February	2nd March
s	s
$66 \cdot 4 \times 10^{-7}$	$55 \cdot 6 \times 10^{-7}$
$65 \cdot 0$	$56 \cdot 8$

The adopted corrections were:—

February	27	Night	s -59×10^{-7}
,,	28	Day	58×10^{-7}
,,	28	Night	-57×10^{-7}
March	1	Day	
,,	1	Night	
,,	2	Day	

These values were obtained by drawing a curve of the same form as that found at Jalpaiguri in 1905, where the circumstances were similar.

Multan.

	°	′	″
Latitude	30	11	11
Longitude	71	25	51
Height above mean sea level		404 feet	

The pendulum station was in a room at the northern corner of a house which stands in the S. E. angle formed by Lake Street and Prince's Road.

The height was determined by levelling from the bench-mark in the compound of the Canal office.

The flexure correction was determined five times:—

	7th March	10th March	11th March
	s	s	s
	$45 \cdot 1 \times 10^{-7}$	$45 \cdot 3 \times 10^{-7}$	$44 \cdot 5 \times 10^{-7}$
	$41 \cdot 3$	...	$45 \cdot 5$
Adopted Correction		s -44×10^{-7}	

This station was very near the road and I do not think that the ground was wholly free from tremors caused by passing traffic. I did not succeed in definitely detecting their effects but I think that the less good agreement between the results of the several sets of observations may probably be ascribed to them.

Jacobabad.

		°	′	″
Latitude	... ...	28	16	34
Longitude	... ...	68	27	5
Height above mean sea level			183 feet	

The pendulum station was situated in the large western room of the Military Works Rest-house. The pillar was about 5800 feet east and 106 feet north of the centre of the railway station. The height was determined by two separate lines of levels, the one to the nearest canal bench-mark and the other to the rails opposite the station platform.

The results differed by 1 foot only.

The flexure correction was determined five times :—

15th March	18th March
s	s
$54{\cdot}7 \times 10^{-7}$	$52{\cdot}1 \times 10^{-7}$
52·5	51·0
53·2	...

Adopted Correction -53×10^{-7} (s)

Sibi.

		°	′	″
Latitude	... ...	29	32	46
Longitude	... ...	67	52	31
Height above mean sea level ...			434 feet	

The pendulum station was in the centre room of the Dâk Bungalow.

The pillar was about 390 feet south and 980 feet east of the centre of the platform of the railway station.

The height was determined by levelling from the railway lines opposite the station.

The flexure correction was determined six times :—

21st March	26th March	27th March
s	s	s
$49{\cdot}4 \times 10^{-7}$	$45{\cdot}6 \times 10^{-7}$	$46{\cdot}9 \times 10^{-7}$
49·0	44·5	46·4

Adopted Correction -48×10^{-7} (s)

Bad weather was met with at this station and stars were obtained on the nights of the 21st, 23rd and 26th only. Therefore, although 5 sets of observations were made, only 2 independent results can be deduced from them.

Mach.

		°	′	″
Latitude	... ...	29	52	25
Longitude	... ...	67	18	20
Height above mean sea level ...			3522 feet	

The pendulum station was situated in the centre room of building No. 36, which stands between the Military Works Inspection House and the Rest-house or Dâk Bungalow, and about

50 yards from the former. The approximate distance and azimuth of the centre of the iron railway bridge on the opposite side of the Bolan River were 2300 feet and 276°.

The height was determined by levelling from the Sibi abutment of the above-mentioned bridge. The height of that point as determined by the railway engineers is 3430·7 feet above mean sea level and the floor of the pendulum room was found to be 91·3 feet above it.

The flexure correction was determined four times :—

29th March	31st March
$40^{s}.5 \times 10^{-7}$	$38^{s}.0 \times 10^{-7}$
39·2	36·6

Adopted Correction $- 39^{s} \times 10^{-7}$

Quetta.

		°	′	″
Latitude	... ...	30	12	15
Longitude	... ...	67	0	41
Height above mean sea level ...			5520 feet	

The pendulum station was situated in the small bungalow in the compound of the C.R.E.'s house, which used formerly to be the Superintending Engineer's office. The C.R.E.'s house stands in the eastern angle formed by the intersection of Phayre Road with Lytton Road. The pendulum pillar was about 126 yards from Phayre Road and 31 yards from Lytton Road. A plane table traverse was made connecting the pendulum station with the Telegraph Office S. at which a latitude and an azimuth had been observed in 1904, and the co-ordinates of which are given in Vol. XV. *Op. G. T. S.* Appendix p. (12).

The height was determined by levelling from the railway station. Rail-level at the station as determined by the railway engineers, is 5501·6 feet.

The flexure correction was determined five times :—

3rd April	6th April
$42^{s}.9 \times 10^{-7}$	$41^{s}.6 \times 10^{-7}$
46·3	40·5
42·9	...

Adopted Correction $- 43^{s} \times 10^{-7}$

Dehra Dun.

On returning to Dehra Dún the closing observations were made in the pendulum room.

The flexure observation was made four times and yielded the following values :—

20th April	26th April
$40^{s}.4 \times 10^{-7}$	$36^{s}.7 \times 10^{-7}$
40·7	37·5

Adopted Correction $- 39^{s} \times 10^{-7}$

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
	Dehra Dun—(Pendulum room). 12-13 November, 1905.														
	h m	s	s	′	°	°		s							s
137	1 17	34·051	+ 5·85	13	21·04	−0·08	0·853	0·5074513	−343	−5	−1031	Not applied	− 507	−43	0·5072584
139	2 14	34·491	5·85	14	21·15	0·08	0·855	0·5073549	343	5	1036		518	43	0·5071604
138	3 23	33·007	5·85	14	20·96	0·08	0·855	0·5076907	343	5	1027		489	43	0·5075000
140	4 20	34·843	5·85	13	20·91	0·08	0·856	0·5072795	343	5	1024		519	43	0·5070861
													Mean	...	0·5072512
137	13 25	34·064	+ 5·85	13	20·71	+0·12	0·857	0·5074485	−343	−5	−1015		− 509	−43	0·5072570
139	14 23	34·500	5·85	15	20·81	0·12	0·857	0·5073528	343	6	1020		519	43	0·5071597
138	15 19	33·015	5·85	16	20·97	0·12	0·856	0·5076888	343	7	1028		490	43	0·5074977
140	16 18	34·848	5·85	10	21·00	0·12	0·855	0·5072786	343	3	1029		518	43	0·5070850
													Mean	...	0·5072499
									Time of Vibration of Mean Pendulum					...	0·5072505
	13-14 November, 1905.														
140	1 23	34·848	+ 5·95	17	20·92	−0·01	0·856	0·5072786	−349	−8	−1025	Not applied	− 519	−43	0·5070842
138	2 22	33·011	5·95	15	21·04	0·01	0·856	0·5076897	349	6	1031		490	43	0·5074978
139	3 19	34·501	5·95	14	20·93	0·01	0·857	0·5073527	349	5	1026		519	43	0·5071585
137	4 16	34·055	5·95	12	20·98	0·01	0·856	0·5074505	349	4	1028		508	43	0·5072573
													Mean	...	0·5072495
140	13 38	34·848	+ 5·95	14	20·62	+0·09	0·859	0·5072785	−349	−5	−1010		− 521	−43	0·5070857
138	14 37	33·014	5·95	14	20·78	0·09	0·857	0·5076889	349	5	1018		490	43	0·5074984
139	15 40	34·498	5·95	14	20·83	0·09	0·857	0·5073532	349	5	1021		519	43	0·5071595
137	16 38	34·052	5·95	12	20·93	0·09	0·856	0·5074511	349	4	1026		508	43	0·5072581
													Mean	...	0·5072504
									Time of Vibration of Mean Pendulum					...	0·5072499
	14-15 November, 1905.														
137	1 27	34·045	+ 6·16	13	20·76	+0·03	0·856	0·5074527	−362	−5	−1017	Not applied	− 508	−43	0·5072592
139	2 24	34·488	6·16	14	20·77	0·03	0·856	0·5073556	362	5	1018		519	43	0·5071609
138	3 19	32·997	6·16	15	20·81	0·03	0·856	0·5076929	362	6	1020		490	43	0·5075008
140	4 14	34·836	6·16	13	20·82	0·03	0·856	0·5072811	362	5	1020		519	43	0·5070862
													Mean	...	0·5072518
137	13 48	34·045	+ 6·16	13	20·58	+0·08	0·858	0·5074527	−362	−5	−1008		− 510	−43	0·5072599
139	14 49	34·495	6·16	14	20·69	0·08	0·857	0·5073540	362	5	1014		519	43	0·5071597
138	15 46	33·004	6·16	16	20·78	0·08	0·857	0·5076915	362	7	1018		490	43	0·5074995
140	16 43	34·841	6·16	14	20·80	0·08	0·856	0·5072800	362	5	1019		519	43	0·5070852
													Mean	...	0·5072511
									Time of Vibration of Mean Pendulum					...	0·5072514
													General Mean	...	0·5072506
	Simla. 15-16 December, 1905.														
	h m	s	s	′	°	°		s							s
137	3 25	34·277	− 2·36	15	10·45	+0·03	0·749	0·5074012	+139	−6	− 512	Not applied	− 445	−35	0·5073153
139	4 22	34·726	2·36	16	10·56	0·03	0·748	0·5073043	139	7	517		453	35	0·5072170
138	5 16	33·215	2·36	17	10·58	0·03	0·747	0·5076417	139	8	518		427	35	0·5075568
140	6 11	35·078	2·36	15	10·56	0·03	0·747	0·5072300	139	6	517		453	35	0·5071428
													Mean	...	0·5073080
137	15 39	34·272	− 2·36	15	10·67	+0·07	0·748	0·5074025	+139	−6	− 523		− 444	−35	0·5073156
139	16 32	34·718	2·36	16	10·67	0·07	0·748	0·5073060	139	7	523		453	35	0·5072181
138	17 26	33·211	2·36	17	10·76	0·07	0·748	0·5076427	139	8	527		428	35	0·5075568
140	18 26	35·074	2·36	14	10·84	0·07	0·748	0·5072308	139	5	531		453	35	0·5071423
													Mean	...	0·5073082
									Time of Vibration of Mean Pendulum					...	0·5073081

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
							16-17 December, 1905.								
	h m	s	s	′	°	°		s							s
140	3 28	35·056	− 2·49	16	11·15	−0·02	0·747	0·5072347	+ 146	− 7	− 546	Not applied	− 453	−35	0·5071452
138	4 21	33·197	2·49	17	11·13	0·02	0·747	0·5076460	146	8	545		427	35	0·5075591
139	5 16	34·705	2·49	16	11·09	0·02	0·746	0·5073089	146	7	543		452	35	0·5072198
137	6 12	34·258	2·49	14	11·11	0·02	0·746	0·5074057	146	5	544		443	35	0·5073176
													Mean	...	0·5073104
140	15 56	35·070	− 2·49	16	10·90	+0·05	0·748	0·5072317	+ 146	− 7	− 534		− 453	−35	0·5071434
138	16 44	33·201	2·49	18	11·00	0·05	0·747	0·5076450	146	9	539		427	35	0·5075586
139	17 32	34·710	2·49	17	11·05	0·05	0·747	0·5073076	146	8	541		453	35	0·5072185
137	19 24	34·256	2·49	14	11·11	0·05	0·747	0·5074061	146	5	544		444	35	0·5073179
													Mean	...	0·5073096
								Time of Vibration of Mean Pendulum						...	**0·5073100**
							17-18 December, 1905.								
139	3 47	34·709	− 2·29	16	11·02	+0·04	0·747	0·5073081	+ 134	− 7	− 540	Not applied	− 453	−35	0·5072180
137	4 43	34·257	2·29	15	11·06	0·04	0·747	0·5074060	134	6	542		444	35	0·5073167
140	5 38	35·063	2·29	16	11·11	0·04	0·746	0·5072331	134	7	544		452	35	0·5071427
138	6 38	33·199	2·29	16	11·11	0·04	0·746	0·5076455	134	7	544		427	35	0·5075576
													Mean	...	0·5073087
139	15 56	34·721	− 2·29	17	10·61	+0·09	0·749	0·5073052	+ 134	− 8	− 520		− 454	−35	0·5072169
137	16 54	34·266	2·29	14	10·86	0·09	0·749	0·5074037	134	5	532		445	35	0·5073154
140	17 41	35·070	2·29	16	10·91	0·09	0·749	0·5072317	134	7	535		454	35	0·5071420
138	18 40	33·204	2·29	17	10·91	0·09	0·748	0·5076443	134	8	535		428	35	0·5075571
													Mean	...	0·5073079
								Time of Vibration of Mean Pendulum						...	**0·5073083**
								General Mean						...	**0·5073088**
							Kalka.								
							22-23 December, 1905.								
	h m	s	s	′	°	°		s							s
137	3 50	34·132	+ 9·19	15	17·58	+0·12	0·867	0·5074333	− 539	− 6	− 861	Not applied	− 515	−42	0·5072370
139	4 44	34·588	9·19	11	17·66	0·12	0·867	0·5073341	539	3	865		525	42	0·5071307
138	5 41	33·074	9·19	17	17·80	0·12	0·865	0·5076748	539	8	872		495	42	0·5074792
140	6 36	34·927	9·19	15	17·87	0·12	0·865	0·5072618	539	6	876		524	42	0·5070631
													Mean	...	0·5072290
137	15 51	34·124	+ 9·19	16	17·79	+0·15	0·868	0·5074352	− 539	− 7	− 872		− 516	−42	0·5072376
139	16 49	34·577	9·19	17	17·95	0·15	0·868	0·5073363	539	8	880		526	42	0·5071368
138	17 49	33·067	9·19	17	18·11	0·15	0·867	0·5076763	539	8	887		496	42	0·5074791
140	18 46	34·914	9·19	16	18·23	0·15	0·867	0·5072646	539	7	893		525	42	0·5070640
													Mean	...	0·5072294
								Time of Vibration of Mean Pendulum						...	**0·5072292**
							Ludhiana.								
							30-31 December, 1905.								
	h m	s	s	′	°	°		s							s
137	4 17	34·395	+ 5·17	17	16·79	+0·08	0·913	0·5073756	−303	− 8	− 823	Not applied	− 542	−43	0·5072037
139	5 11	34·848	5·17	18	16·90	0·08	0·913	0·5072786	303	9	828		553	43	0·5071050
138	6 11	33·328	5·17	16	16·99	0·08	0·913	0·5076153	303	7	833		522	43	0·5074445
140	7 8	35·206	5·17	14	17·02	0·08	0·913	0·5072035	303	5	834		553	43	0·5070297
													Mean		0·5071957
137	16 24	34·386	+ 5·17	15	16·71	+0·07	0·916	0·5073776	−303	− 6	− 819		− 544	−43	0·5072061
139	17 19	34·840	5·17	15	16·79	0·07	0·916	0·5072800	303	6	823		555	43	0·5071070
138	18 30	33·320	5·17	19	16·86	0·07	0·914	0·5076173	303	10	826		523	43	0·5074468
140	19 25	35·197	5·17	17	16·91	0·07	0·914	0·5072053	303	8	829		554	43	0·5070316
													Mean	...	0·5071979
								Time of Vibration of Mean Pendulum						...	**0·5071968**

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
31 December, 1905—1 January, 1906.															
	h m	s	s	′	°	°		s							s
140	4 23	35·170	+ 6·33	17	17·04	+0·04	0·916	0·5072108	−372	− 8	− 835	Not applied	− 555	−43	0·5070295
138	5 22	33·297	6·33	18	16·92	0·04	0·916	0·5076226	372	9	829		524	43	0·5074449
139	6 18	34·816	6·33	17	16·94	0·04	0·916	0·5072852	372	8	830		555	43	0·5071044
137	7 17	34·362	6·33	15	17·17	0·04	0·915	0·5073830	372	6	841		544	43	0·5072024
													Mean	...	0·5071953
140	16 26	35·167	+ 6·33	17	16·56	−0·02	0·918	0·5072115	−372	− 8	− 811		− 556	−43	0·5070325
138	17 25	33·293	6·33	18	16·63	0·02	0·918	0·5076237	372	9	815		525	43	0·5074473
139	18 21	34·811	6·33	18	16·53	0·02	0·917	0·5072863	372	9	810		556	43	0·5071073
137	19 22	34·363	6·33	16	16·59	0·02	0·917	0·5073827	372	7	813		545	43	0·5072047
													Mean	...	0·5071979
								Time of Vibration of Mean Pendulum						...	0·5071966
2-3 January, 1906.															
139	4 30	34·787	+ 7·57	17	16·65	+0·04	0·916	0·5072915	−444	− 8	− 816	Not applied	− 555	−43	0·5071049
137	5 29	34·335	7·57	14	16·78	0·04	0·914	0·5073888	444	5	822		543	43	0·5072031
140	6 25	35·141	7·57	15	16·76	0·04	0·916	0·5072167	444	6	821		555	43	0·5070298
138	7 23	33·271	7·57	16	16·83	0·04	0·914	0·5076288	444	7	825		523	43	0·5074446
													Mean	...	0·5071956
139	16 38	34·784	+ 7·57	17	16·41	+0·07	0·919	0·5072921	−444	− 8	− 804		− 557	−43	0·5071065
137	17 38	34·335	7·57	13	16·44	0·07	0·919	0·5073888	444	5	806		546	43	0·5072044
140	18 38	35·146	7·57	15	16·52	0·07	0·918	0·5072158	444	6	809		556	43	0·5070300
138	19 37	33·271	7·57	17	16·59	0·07	0·918	0·5076287	444	8	813		525	43	0·5074454
													Mean	...	0·5071966
								Time of Vibration of Mean Pendulum						...	0·5071961
3-4 January, 1906.															
138	4 25	33·258	+ 7·94	18	16·85	+0·06	0·918	0·5076316	−466	− 9	− 826	Not applied	− 525	−43	0·5074447
140	5 20	35·123	7·94	15	16·91	0·06	0·917	0·5072206	466	6	829		556	43	0·5070306
137	6 13	34·319	7·94	15	16·95	0·06	0·917	0·5073922	466	6	831		545	43	0·5072031
139	7 5	34·765	7·94	16	17·02	0·06	0·917	0·5072960	466	7	834		556	43	0·5071054
													Mean	...	0·5071959
138	16 45	33·270	+ 7·94	18	15·92	+0·04	0·923	0·5076288	−466	− 9	− 780		− 528	−43	0·5074462
140	17 37	35·138	7·94	15	16·03	0·04	0·922	0·5072175	466	6	785		559	43	0·5070316
137	18 30	34·339	7·94	14	16·05	0·04	0·922	0·5073878	466	5	786		548	43	0·5072030
139	19 23	34·784	7·94	15	16·05	0·04	0·920	0·5072922	466	6	786		558	43	0·5071063
													Mean	...	0·5071968
								Time of Vibration of Mean Pendulum						...	0·5071964
													General Mean	...	0·5071965

Mian Mir.

10-11 January, 1906.

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
	h m	s	s	′	°	°		s							s
137	5 22	34·617	+ 4·19	16	14·43	+0·16	0·929	0·5073277	− 246	− 7	− 707	Not applied	− 552	−39	0·5071726
139	6 17	35·061	4·19	16	14·68	0·16	0·928	0·5072335	246	7	719		562	39	0·5070762
138	7 11	33·522	4·19	17	14·78	0·16	0·928	0·5075707	246	8	724		531	39	0·5074159
140	8 0	35·420	4·19	16	14·89	0·16	0·926	0·5071593	246	7	730		561	39	0·5070010
													Mean	...	0·5071664
137	17 18	34·590	+ 4·19	16	14·69	+0·01	0·930	0·5073336	− 246	− 7	− 720		− 552	−39	0·5071772
139	18 10	35·047	4·19	17	14·76	0·01	0·929	0·5072366	246	8	723		563	39	0·5070787
138	19 4	33·506	4·19	17	14·73	0·01	0·929	0·5075743	246	8	722		531	39	0·5074197
140	19 58	35·404	4·19	16	14·74	0·01	0·929	0·5071625	246	7	722		563	39	0·5070048
													Mean	...	0·5071701
								Time of Vibration of Mean Pendulum						...	0·5071683

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
	11-12 January, 1906.														
	h m	s	s	′	°	°		s							s
140	5 15	35·390	+ 4·85	17	15·37	+0·02	0·925	0·5071653	− 285	− 8	− 753	Not applied	− 561	−39	0·5070007
138	6 14	33·496	4·85	17	15·39	0·02	0·925	0·5075768	285	8	754		529	39	0·5074153
139	7 11	35·028	4·85	16	15·41	0·02	0·925	0·5072406	285	7	755		561	39	0·5070759
137	8 9	34·568	4·85	14	15·43	0·02	0·925	0·5073383	285	5	756		549	39	0·5071749
													Mean	...	0·5071667
140	17 16	35·390	+ 4·85	17	15·00	−0·01	0·931	0·5071653	− 285	− 8	− 735		− 564	−39	0·5070022
138	18 13	33·491	4·85	17	14·95	0·01	0·931	0·5075779	285	8	733		533	39	0·5074181
139	19 11	35·026	4·85	16	14·94	0·01	0·931	0·5072410	285	7	732		564	39	0·5070783
137	20 10	34·568	4·85	14	14·99	0·01	0·931	0·5073385	285	5	735		553	39	0·5071768
													Mean	...	0·5071689
													Time of Vibration of Mean Pendulum	...	**0·5071678**
	12-13 January, 1906.														
139	5 27	35·004	+ 5·44	17	15·36	+0·04	0·929	0·5072456	− 319	− 8	− 753	Not applied	− 563	−39	0·5070774
137	6 22	34·547	5·44	14	15·43	0·04	0·929	0·5073428	319	5	756		552	39	0·5071757
140	7 17	35·364	5·44	17	15·46	0·04	0·929	0·5071707	319	8	758		563	39	0·5070020
138	8 15	33·465	5·44	17	15·48	0·04	0·928	0·5075838	319	8	759		531	39	0·5074182
													Mean	...	0·5071683
139	17 26	35·012	+ 5·44	18	14·91	+0·03	0·930	0·5072437	− 319	− 9	− 731		− 564	−39	0·5070775
137	18 21	34·552	5·44	15	15·09	0·03	0·929	0·5073417	319	6	739		552	39	0·5071762
140	19 16	35·372	5·44	18	15·06	0·03	0·929	0·5071691	319	9	738		563	39	0·5070023
138	20 16	33·478	5·44	19	15·06	0·03	0·929	0·5075809	319	10	738		531	39	0·5074172
													Mean	...	0·5071683
													Time of Vibration of Mean Pendulum	...	**0·5071683**
													General Mean	...	**0·5071681**
	Ferozepore.														
	17-18 January, 1906.														
	h m	s	s	′	°	°		s							s
137	9 14	34·585	+ 3·27	17	13·87	0·00	0·930	0·5073347	− 192	− 8	− 680	Not applied	− 552	−50	0·5071865
139	10 12	35·040	3·27	17	13·90	0·00	0·930	0·5072379	192	8	681		564	50	0·5070884
138	11 11	33·503	3·27	18	13·89	0·00	0·930	0·5075750	192	9	681		532	50	0·5074286
140	12 9	35·404	3·27	16	13·88	0·00	0·930	0·5071625	192	7	680		564	50	0·5070132
													Mean	...	0·5071792
137	21 13	34·591	+ 3·27	15	13·74	0·00	0·932	0·5073332	− 192	− 6	− 673		− 554	−50	0·5071857
139	22 15	35·047	3·27	16	13·73	0·00	0·932	0·5072365	192	7	673		565	50	0·5070878
138	23 15	33·503	3·27	17	13·73	0·00	0·932	0·5075750	192	8	673		533	50	0·5074294
140	0 19	35·397	3·27	19	13·74	0·00	0·931	0·5071638	192	10	673		564	50	0·5070149
													Mean	...	0·5071795
													Time of Vibration of Mean Pendulum	...	**0·5071793**
	18-19 January, 1906.														
140	9 3	35·392	+ 3·58	18	14·04	+0·08	0·930	0·5071650	− 210	− 9	− 688	Not appled	− 564	−50	0·5070129
138	10 4	33·493	3·58	17	14·23	0·08	0·929	0·5075773	210	8	697		531	50	0·5074277
139	11 1	35·027	3·58	17	14·28	0·08	0·929	0·5072408	210	8	700		563	50	0·5070877
137	11 57	34·565	3·58	15	14·32	0·08	0·929	0·5073390	210	6	702		552	50	0·5071870
													Mean	...	0·5071788
140	21 11	35·393	+ 3·58	16	13·96	+0·05	0·932	0·5071648	− 210	− 7	− 684		− 565	−50	0·5070132
138	22 10	33·496	3·58	17	14·08	0·05	0·932	0·5075767	210	8	690		533	50	0·5074276
139	23 9	35·028	3·58	16	14·10	0·05	0·931	0·5072403	210	7	691		564	50	0·5070881
137	0 9	34·573	3·58	14	14·12	0·05	0·931	0·5073371	210	5	692		553	50	0·5071861
													Mean	...	0·5071788
													Time of Vibration of Mean Pendulum	...	**0·5071788**

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Correction on account of: Arc	Correction on account of: Temperature	Correction on account of: Lag	Correction on account of: Density of Air	Correction on account of: Flexure	Reduced Time of Vibration
							20-21 January, 1906.								
	h m	s	s	′	°	°		s							s
139	9 16	34·998	+ 4·29	17	14·70	+0·03	0·925	0·5072468	−252	− 8	− 720	Not applied	− 561	−48	0·5070879
137	10 15	34·540	4·29	14	14·79	0·03	0·925	0·5073442	252	5	725		549	48	0·5071863
140	11 13	35·358	4·29	16	14·79	0·03	0·925	0·5071718	252	7	725		561	48	0·5070125
138	12 12	33·464	4·29	17	14·82	0·03	0·925	0·5075840	252	8	726		529	48	0·5074277
													Mean	...	0·5071786
139	21 17	34·997	+ 4·29	18	14·43	+0·10	0·928	0·5072470	−[illegible]52	− 9	− 707		− 562	−48	0·5070892
137	22 21	34·539	4·29	16	14·50	0·10	0·928	0·5073445	252	7	711		551	48	0·5071876
140	23 18	35·355	4·29	17	14·63	0·10	0·925	0·5071727	252	8	717		561	48	0·5070141
138	0 15	33·461	4·29	19	14·68	0·10	0·925	0·5075848	252	10	719		529	48	0·5074290
													Mean	...	0·5071799
									Time of Vibration of Mean Pendulum					...	**0·5071793**
													General Mean	...	**0·5071791**
							Pathankot.								
							2-3 February, 1906.								
	h m	s	s	′	°	°		s							s
137	6 26	34·497	+ 0·61	16	16·06	+0·11	0·907	0·5073536	− 36	− 7	− 787	Not applied	− 539	−40	0·5072127
139	7 22	34·949	0·61	18	16·29	0·11	0·906	0·5072570	36	9	798		549	40	0·5071138
138	8 20	33·419	0·61	18	16·36	0·11	0·904	0·5075942	36	9	802		517	40	0·5074538
140	9 16	35·294	0·61	17	16·41	0·11	0·904	0·5071852	36	8	804		548	40	0·5070416
													Mean	...	0·5072055
137	18 21	34·488	+ 0·61	17	16·00	+0·08	0·911	0·5073556	− 36	− 8	− 784		− 541	−40	0·5072147
139	19 17	34·950	0·61	18	16·09	0·08	0·911	0·5072568	36	9	788		552	40	0·5071143
138	20 12	33·420	0·61	19	16·18	0·08	0·911	0·5075940	36	10	793		521	40	0·5074540
140	21 10	35·308	0·61	17	16·23	0·08	0·911	0·5071823	36	8	795		552	40	0·5070392
													Mean	...	0·5072056
									Time of Vibration of Mean Pendulum					...	**0·5072055**
							3-4 February, 1906.								
140	6 6	35·311	+ 0·43	18	15·93	+0·01	0·912	0·5071816	− 25	− 9	− 781	Not applied	− 553	−40	0·5070408
138	7 6	33·421	0·43	18	15·99	0·01	0·909	0·5075940	25	9	784		520	40	0·5074562
139	8 3	34·947	0·43	18	15·98	0·01	0·911	0·5072576	25	9	783		552	40	0·5071167
137	9 0	34·497	0·43	16	15·98	0·01	0·911	0·5073535	25	7	783		541	40	0·5072139
													Mean	...	0·5072069
140	18 8	35·312	+ 0·43	18	15·54	+0·13	0·914	0·5071813	− 25	− 9	− 761		− 554	−40	0·5070424
138	19 4	33·425	0·43	19	15·68	0·13	0·913	0·5075931	25	10	768		522	40	0·5074566
139	19 59	34·952	0·43	18	15·81	0·13	0·913	0·5072563	25	9	775		553	40	0·5071161
137	20 55	34·499	0·43	16	15·89	0·13	0·912	0·5073531	25	7	779		542	40	0·5072138
													Mean	...	0·5072072
									Time of Vibration of Mean Pendulum					...	**0·5072071**
							4-5 February, 1906.								
139	6 22	34·952	+ 0·72	18	15·85	+0·05	0·912	0·5072565	− 42	− 9	− 777	Not applied	− 553	−40	0·5071144
137	7 20	34·489	0·72	16	15·97	0·05	0·911	0·5073555	42	7	783		541	40	0·5072142
140	8 21	35·302	0·72	17	15·94	0·05	0·912	0·5071835	42	8	781		553	40	0·5070411
138	9 20	33·420	0·72	17	16·06	0·05	0·911	0·5075942	42	8	787		521	40	0·5074544
													Mean	...	0·5072060
139	18 30	34·945	+ 0·72	19	15·87	+0·11	0·910	0·5072580	− 42	−10	− 778		− 551	−40	0·5071159
137	19 26	34·491	0·72	16	15·99	0·11	0·909	0·5073548	42	7	784		540	40	0·5072135
140	20 24	35·301	0·72	21	16·10	0·11	0·909	0·5071838	42	12	789		551	40	0·5070404
138	21 23	33·425	0·72	16	16·19	0·11	0·908	0·5075929	42	7	793		519	40	0·5074528
													Mean	...	0·5072056
									Time of Vibration of Mean Pendulum					...	**0·5072058**
													General Mean	...	**0·5072061**

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
							Montgomery.								
							17-18 February, 1906.								
	h m	s	s	′	°	°		s							s
137	7 40	34·592	+ 0·39	17	16·16	+0·06	0·922	0·5073331	− 23	− 8	− 792	Not applied	− 548	−41	0·5071919
139	8 39	35·049	0·39	18	16·23	0·06	0·922	0·5072360	23	9	795		559	41	0·5070933
138	9 43	33·519	0·39	18	16·31	0·06	0·922	0·5075715	23	9	799		527	41	0·5074316
140	10 44	35·412	0·39	17	16·32	0·06	0·920	0·5071609	23	8	800		558	41	0·5070179
													Mean	...	0·5071837
137	19 40	34·574	+ 0·39	18	16·49	+0·04	0·921	0·5073370	− 23	− 9	− 808		− 547	−41	0·5071942
139	20 44	35·048	0·39	17	16·53	0·04	0·919	0·5072362	23	8	810		557	41	0·5070923
138	21 49	33·513	0·39	18	16·58	0·04	0·919	0·5075727	23	9	812		526	41	0·5074316
140	22 55	35·406	0·39	15	16·60	0·04	0·919	0·5071621	23	6	813		557	41	0·5070181
													Mean	...	0·5071841
										Time of Vibration of Mean Pendulum				...	**0·5071839**
							18-19 February, 1906.								
140	7 25	35·391	+ 0·57	19	16·58	−0·07	0·918	0·5071652	− 33	−10	− 812	Not applied	− 556	−41	0·5070200
138	8 28	33·503	0·57	19	16·56	0·07	0·918	0·5075752	33	10	811		525	41	0·5074332
139	9 28	35·042	0·57	19	16·49	0·07	0·918	0·5072377	33	10	808		556	41	0·5070929
137	10 30	34·589	0·57	17	16·39	0·07	0·918	0·5073338	33	8	803		545	41	0·5071908
													Mean	...	0·5071842
140	19 41	35·384	+ 0·57	19	16·83	+0·08	0·917	0·5071665	− 33	−10	− 825		− 556	−41	0·5070200
138	20 42	33·489	0·57	16	16·81	0·08	0·917	0·5075782	33	7	824		525	41	0·5074352
139	21 43	35·031	0·57	16	16·94	0·08	0·917	0·5072398	33	7	830		556	41	0·5070931
137	22 43	34·567	0·57	16	17·01	0·08	0·917	0·5073385	33	7	833		545	41	0·5071926
													Mean	...	0·5071852
										Time of Vibration of Mean Pendulum				...	**0·5071847**
							19-20 February, 1906.								
139	7 34	35·027	+ 0·73	19	16·73	−0·08	0·917	0·5072408	− 43	−10	− 820	Not applied	− 556	−41	0·5070938
137	8 38	34·568	0·73	17	16·73	0·08	0·918	0·5073382	43	8	820		545	41	0·5071925
140	9 40	35·392	0·73	18	16·58	0·08	0·919	0·5071650	43	9	812		557	41	0·5070188
138	10 41	33·497	0·73	19	16·56	0·08	0·919	0·5075763	43	10	811		526	41	0·5074332
													Mean	...	0·5071846
139	19 54	35·024	+ 0·73	18	16·95	+0·05	0·922	0·5072411	− 43	− 9	− 831		− 559	−41	0·5070928
137	20 54	34·565	0·73	17	16·99	0·05	0·922	0·5073390	43	8	833		548	41	0·5071917
140	21 54	35·380	0·73	19	17·0	0·05	0·921	0·5071672	43	10	837		558	41	0·5070183
138	23 11	33·485	0·73	22	17·06	0·05	0·921	0·5075792	43	13	836		527	41	0·5074332
													Mean	...	0·5071840
										Time of Vibration of Mean Pendulum				...	**0·5071843**
													General Mean	...	**0·5071843**
							Dera Ghazi Khan.								
							27-28 February, 1906.								
	h m	s	s	′	°	°		s							s
137	7 54	34·603	− 4·86	17	14·46	+0·10	0·944	0·5073307	+285	− 8	− 709	Not applied	− 561	−59	0·5072255
139	8 59	35·063	4·86	18	14·67	0·10	0·943	0·5072331	285	9	719		571	59	0·5071258
138	10 3	33·518	4·86	16	14·73	0·10	0·943	0·5075718	285	7	722		539	59	0·5074676
140	11 5	35·412	4·86	22	14·80	0·10	0·943	0·5071609	285	12	725		571	59	0·5070527
													Mean	...	0·5072179
137	20 9	34·586	− 4·86	18	15·04	−0·04	0·943	0·5073345	+285	− 9	− 737		− 560	−58	0·5072266
139	21 11	35·043	4·86	18	14·96	0·04	0·943	0·5072373	285	9	733		571	58	0·5071287
138	22 14	33·511	4·86	19	14·93	0·04	0·941	0·5075735	285	10	732		538	58	0·5074682
140	23 13	35·405	4·86	17	14·93	0·04	0·940	0·5071623	285	8	732		570	58	0·5070540
													Mean	...	0·5072194
										Time of Vibration of Mean Pendulum				...	**0·5072186**

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
28 February—1 March, 1906.															
	h m	s	s	′	°	°		s							s
140	7 59	35·392	− 4·11	19	15·19	+0·04	0·939	0·5071649	+241	−10	− 744	Not applied	− 569	−57	0·5070510
138	9 5	33·501	4·11	18	15·21	0·04	0·939	0·5075755	241	9	745		537	57	0·5074648
139	10 4	35·034	4·11	18	15·25	0·04	0·938	0·5072392	241	9	747		568	57	0·5071252
137	11 3	34·567	4·11	19	15·31	0·04	0·938	0·5073385	241	10	750		557	57	0·5072252
													Mean	...	0·5072166
140	20 2	35·388	− 4·11	19	15·13	0·00	0·939	0·5071656	+241	−10	− 741		− 569	−57	0·5070520
138	21 2	33·498	4·11	20	15·11	0·00	0·939	0·5075761	241	11	740		537	57	0·5074657
139	22 1	35·034	4·11	18	15·11	0·00	0·939	0·5072392	241	9	740		569	57	0·5071258
137	23 1	34·569	4·11	18	15·13	0·00	0·938	0·5073381	241	9	741		557	57	0·5072258
													Mean	...	0·5072173
								Time of Vibration of Mean Pendulum						...	**0·5072169**
1-2 March, 1906.															
139	7 55	35·015	− 3·93	19	15·56	−0·02	0·934	0·5072430	+231	−10	− 762	Not applied	− 566	−57	0·5071266
137	8 54	34·550	3·93	18	15·57	0·02	0·934	0·5073422	231	9	763		555	57	0·5072269
140	9 54	35·377	3·93	18	15·53	0·02	0·935	0·5071680	231	9	761		567	57	0·5070517
138	10 52	33·480	3·93	18	15·53	0·02	0·935	0·5075803	231	9	761		535	57	0·5074672
													Mean	...	0·5072181
139	20 7	35·011	− 3·93	19	15·66	−0·01	0·937	0·5072441	+231	−10	− 767		− 568	−57	0·5071270
137	21 8	34·559	3·93	18	15·62	0·01	0·937	0·5073402	231	9	765		557	57	0·5072245
140	22 7	35·572	3·93	18	15·62	0·01	0·937	0·5071690	231	9	765		568	57	0·5070522
138	23 13	33·487	3·93	18	15·64	0·01	0·937	0·5075787	231	9	766		536	57	0·5074650
													Mean	...	0·5072172
								Time of Vibration of Mean Pendulum						...	**0·5072176**
													General Mean	...	**0·5072177**
Multan.															
7-8 March, 1906.															
	h m	s	s	′	°	°		s							s
137	8 52	34·547	− 1·68	18	16·91	+0·03	0·928	0·5073428	+ 99	− 9	− 829	Not applied	− 551	−44	0·5072094
139	9 51	35·002	1·68	19	17·00	0·03	0·928	0·5072459	99	10	833		562	44	0·5071109
138	10 48	33·462	1·68	19	17·03	0·03	0·927	0·5075845	99	10	834		530	44	0·5074526
140	11 46	35·349	1·68	19	16·98	0·03	0·927	0·5071737	99	10	832		562	44	0·5070388
													Mean	...	0·5072029
137	20 43	34·536	− 1·68	20	16·64	+0·12	0·929	0·5073452	+ 99	−11	− 815		− 552	−44	0·5072129
139	21 42	34·999	1·68	19	16·81	0·12	0·927	0·5072465	99	10	824		562	44	0·5071124
138	22 41	33·463	1·68	19	16·92	0·12	0·927	0·5075843	99	10	829		530	44	0·5074529
140	23 42	35·350	1·68	18	17·00	0·12	0·926	0·5071735	99	9	833		561	44	0·5070387
													Mean	...	0·5072042
								Time of Vibration of Mean Pendulum						...	**0·5072036**
8-9 March, 1906.															
140	8 40	35·330	− 1·27	20	17·32	+0·06	0·922	0·5071777	+ 75	−11	− 849	Not applied	− 559	−44	0·5070389
138	9 39	33·438	1·27	19	17·38	0·06	0·921	0·5075901	75	10	852		527	44	0·5074543
139	10 36	34·969	1·27	18	17·43	0·06	0·920	0·5072528	75	9	854		558	44	0·5071138
137	11 36	34·507	1·27	19	17·50	0·06	0·920	0·5073513	75	10	858		546	44	0·5072130
													Mean	...	0·5072050
140	20 53	35·321	− 1·27	20	17·43	+0·08	0·922	0·5071797	+ 75	−11	− 854		− 559	−44	0·5070404
138	21 53	33·429	1·27	19	17·51	0·08	0·922	0·5075921	75	10	858		527	44	0·5074557
139	22 55	34·964	1·27	18	17·59	0·08	0·922	0·5072538	75	9	862		559	44	0·5071139
137	23 55	34·502	1·27	19	17·65	0·08	0·921	0·5073525	75	10	865		547	44	0·5072134
													Mean	...	0·5072059
								Time of Vibration of Mean Pendulum						...	**0·5072054**

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
	9-10 March, 1906.														
	h m	s	s	′	°	°		s							s
139	8 53	34·951	− 0·93	20	18·15	−0·02	0·921	0·5072566	+ 55	−11	− 889	Not applied	− 558	−44	0·5071119
137	9 50	34·484	0·93	20	18·08	0·02	0·921	0·5073562	55	11	886		547	44	0·5072129
140	10 47	35·304	0·93	19	18·03	0·02	0·921	0·5071830	55	10	883		558	44	0·5070390
138	11 47	33·425	0·93	18	18·12	0·02	0·921	0·5075930	55	9	888		527	44	0·5074517
													Mean	...	0·5072039
139	21 5	34·954	− 0·93	20	17·72	+0·09	0·923	0·5072561	+ 55	−11	− 868		− 559	−44	0·5071134
137	22 10	34·490	0·93	18	17·83	0·09	0·922	0·5073549	55	9	874		548	44	0·5072129
140	23 6	35·305	0·93	19	17·91	0·09	0·921	0·5071830	55	10	878		558	44	0·5070395
138	0 7	33·417	0·93	19	17·98	0·09	0·920	0·5075949	55	10	881		526	44	0·5074543
													Mean	...	0·5072050
											Time of Vibration of Mean Pendulum			...	**0·5072045**
													General Mean	...	**0·5072045**
	Jacobabad.														
	15-16 March, 1906.														
	h m	s	s	′	°	°		s							s
137	9 4	34·355	− 1·35	18	21·14	−0·04	0·919	0·5073845	+ 79	− 9	−1036	Not applied	− 546	−53	0·5072280
139	10 2	34·819	1·35	19	21·16	0·04	0·918	0·5072847	79	10	1037		556	53	0·5071270
138	11 0	33·297	1·35	19	21·15	0·04	0·918	0·5076227	79	10	1036		525	53	0·5074682
140	11 58	35·172	1·35	18	20·99	0·04	0·919	0·5072105	79	9	1029		557	53	0·5070536
													Mean	...	0·5072192
137	21 3	34·360	− 1·35	19	21·06	+0·06	0·921	0·5073833	+ 79	−10	−1032		− 547	−53	0·5072270
139	22 5	34·814	1·35	20	21·13	0·06	0·919	0·5072858	79	11	1035		557	53	0·5071281
138	23 5	33·297	1·35	19	21·19	0·06	0·919	0·5076228	79	10	1038		526	53	0·5074680
140	0 7	35·168	1·35	18	21·24	0·06	0·918	0·5072112	79	9	1041		556	53	0·5070532
													Mean	...	0·5072191
											Time of Vibration of Mean Pendulum			...	**0·5072191**
	16-17 March, 1906.														
140	9 16	35·164	− 0·99	18	21·36	+0·04	0·916	0·5072121	+ 58	− 9	−1047	Not applied	− 555	−53	0·5070515
138	10 13	33·291	0·99	19	21·44	0·04	0·916	0·5076241	58	10	1051		524	53	0·5074661
139	11 14	34·810	0·99	19	21·46	0·04	0·916	0·5072865	58	10	1052		555	53	0·5071253
137	12 12	34·345	0·99	19	21·47	0·04	0·916	0·5073867	58	10	1052		544	53	0·5072266
													Mean	...	0·5072174
140	21 24	35·136	− 0·99	18	22·16	−0·01	0·915	0·5072179	+ 58	− 9	−1086		− 554	−53	0·5070535
138	22 23	33·266	0·99	19	22·15	0·01	0·915	0·5076299	58	10	1085		523	53	0·5074686
139	23 26	34·778	0·99	18	22·14	0·01	0·915	0·5072932	58	9	1085		554	53	0·5071349
137	0 32	34·325	0·99	18	22·14	0·01	0·914	0·5073911	58	9	1085		543	53	0·5072279
													Mean	...	0·5072212
											Time of Vibration of Mean Pendulum			...	**0·5072193**
	17-18 March, 1906.														
139	9 7	34·775	− 0·77	22	22·18	−0·05	0·912	0·5072940	+ 45	−13	−1087	Not applied	− 553	−53	0·5071279
137	10 3	34·324	0·77	17	22·17	0·05	0·912	0·5073912	45	8	1086		542	53	0·5072268
140	11 3	35·130	0·77	19	22·09	0·05	0·914	0·5072192	45	10	1082		554	53	0·5070538
138	12 1	33·266	0·77	20	22·07	0·05	0·914	0·5076298	45	11	1081		523	53	0·5074675
													Mean	...	0·5072190
139	21 19	34·785	− 0·77	17	21·73	+0·09	0·917	0·5072917	+ 45	− 8	−1065		− 556	−53	0·5071280
137	22 23	34·330	0·77	19	21·82	0·09	0·917	0·5073899	45	10	1069		545	53	0·5072267
140	23 28	35·133	0·77	19	21·92	0·09	0·917	0·5072186	45	10	1074		556	53	0·5070538
138	0 31	33·265	0·77	18	22·01	0·09	0·916	0·5076300	45	9	1078		524	53	0·5074681
													Mean	...	0·5072192
											Time of Vibration of Mean Pendulum			...	**0·5072191**
													General Mean	...	**0·5072192**

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
							Sibi.								
							21-22 March, 1906.								
	h m	s	s	′	°	°		s							s
137	10 2	34·296	− 3·40	20	23·18	+0·01	0·902	0·5073973	+ 200	−11	−1136	Not applied	− 536	−48	0·5072442
139	11 3	34·755	3·40	19	23·09	0·01	0·902	0·5072981	200	10	1131		547	48	0·5071445
138	12 1	33·240	3·40	19	23·15	0·01	0·901	0·5076360	200	10	1134		515	48	0·5074853
140	12 58	35·105	3·40	20	23·15	0·01	0·901	0·5072243	200	11	1134		546	48	0·5070704
													Mean	...	0·5072361
137	21 53	34·300	− 3·40	19	22·99	+0·02	0·903	0·5073963	+ 200	−10	−1127		− 536	−48	0·5072442
139	22 52	34·755	3·40	19	23·01	0·02	0·903	0·5072982	200	10	1127		547	48	0·5071450
138	23 54	33·244	3·40	18	23·02	0·02	0·903	0·5076350	200	9	1128		517	48	0·5074848
140	0 55	35·105	3·40	20	23·04	0·02	0·902	0·5072243	200	11	1129		547	48	0·5070708
													Mean	...	0·5072362
							22-23 March, 1906.								
140	9 56	35·114	− 3·40	19	22·68	+0·04	0·903	0·5072223	+ 200	− 10	−1111	Not applied	− 547	−48	0·5070707
138	10 57	33·249	3·40	19	22·73	0·04	0·902	0·5076340	200	10	1114		516	48	0·5074852
139	11 55	34·761	3·40	20	22·77	0·04	0·900	0·5072970	200	11	1116		545	48	0·5071450
137	12 52	34·301	3·40	20	22·79	0·04	0·899	0·5073961	200	11	1117		534	48	0·5072451
													Mean	...	0·5072365
140	22 5	35·100	− 3·40	18	22·77	+0·10	0·902	0·5072252	+ 200	− 9	−1116		− 547	−48	0·5070732
138	23 3	33·236	3·40	19	22·90	0·10	0·900	0·5076370	200	10	1122		515	48	0·5074875
139	0 6	34·746	3·40	18	22·99	0·10	0·900	0·5073000	200	9	1127		545	48	0·5071471
137	1 3	34·288	3·40	19	23·07	0·10	0·899	0·5073991	200	10	1130		534	48	0·5072469
													Mean	...	0·5072387
								Time of Vibration of Mean Pendulum (Mean of two sets)						...	**0·5072369**
							23-24 March, 1906.								
139	9 55	34·748	− 2·72	19	22·79	0·00	0·899	0·5072998	+ 160	−10	−1117	Not applied	− 545	−48	0·5071438
137	10 54	34·291	2·72	19	22·85	0·00	0·899	0·5073985	160	10	1120		534	48	0·5072433
140	11 48	35·095	2·72	19	22·79	0·00	0·899	0·5072266	160	10	1117		545	48	0·5070706
138	12 47	33·232	2·72	19	22·84	0·00	0·899	0·5076377	160	10	1119		514	48	0·5074846
													Mean	...	0·5072356
139	22 2	34·747	− 2·72	18	22·78	+0·11	0·902	0·5072999	+ 160	− 9	−1116		− 547	−48	0·5071439
137	23 4	34·288	2·72	18	22·91	0·11	0·902	0·5073990	160	9	1123		536	48	0·5072434
140	0 5	35·091	2·72	18	23·02	0·11	0·902	0.5072273	160	9	1128		547	48	0·5070701
138	1 5	33·230	2·72	19	23·09	0·11	0·900	0·5076383	160	10	1131		515	48	0·5074839
													Mean	...	0·5072353
								Time of Vibration of Mean Pendulum						...	**0·5072355**
							24-25 March, 1906.								
138	9 2	33·239	− 2·72	18	22·59	+0·04	0·903	0·5076361	+ 160	− 9	−1107	Not applied	− 517	−48	0·5074840
140	9 59	35·099	2·72	19	22·73	0·04	0·904	0·5072257	160	10	1114		548	48	0·5070697
137	11 1	34·290	2·72	18	22·73	0·04	0·904	0·5073986	160	9	1114		537	48	0·5072438
139	11 58	34·747	2·72	18	22·72	0·04	0·904	0·5072999	160	9	1113		548	48	0·5071441
													Mean	...	0·5072354
138	21 20	33·235	− 2·72	18	22·54	+0·15	0·906	0·5076371	+ 160	− 9	−1104		− 518	−48	0·5074852
140	22 41	35·092	2·72	16	22·74	0·15	0·906	0·5072270	160	7	1114		549	48	0·5070712
137	23 27	34·287	2·72	19	22·84	0·15	0·905	0·5073993	160	10	1119		538	48	0·5072438
139	0 21	34·738	2·72	19	22·96	0·15	0·904	0·5073017	160	10	1125		548	48	0·5071446
													Mean	...	0·5072362

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
								25-26 March, 1906.							
	h m	s	s	′	°	°		s							s
139	9 4	34.736	− 2.72	18	22.51	+0.03	0.906	0.5073022	+ 160	− 9	− 1103	Not applied	− 549	− 48	0.5071473
137	10 2	34.282	2.72	18	22.59	0.03	0.906	0.5074005	160	9	1107		538	48	0.5072463
140	11 4	35.097	2.72	18	22.61	0.03	0.906	0.5072260	160	9	1108		549	48	0.5070706
138	12 5	33.229	2.72	20	22.62	0.03	0.905	0.5076386	160	11	1108		518	48	0.5074861
													Mean	...	0.5072376
139	21 14	34.727	− 2.72	18	22.98	+0.06	0.905	0.5073042	+ 160	− 9	− 1126		− 548	− 48	0.5071471
137	22 17	34.271	2.72	19	23.08	0.06	0.905	0.5074029	160	10	1131		538	48	0.5072462
140	23 16	35.071	2.72	18	23.14	0.06	0.905	0.5072315	160	9	1134		548	48	0.5070736
138	0 18	33.214	2.72	19	23.13	0.06	0.904	0.5076421	160	10	1133		517	48	0.5074873
													Mean	...	0.5072385
													Time of Vibration of Mean Pendulum	...	0.5072364
													(Mean of three sets)		
													General Mean	...	0.5072367
								Mach.							
								29-30 March, 1906.							
	h m	s	s	′	°	°		s							s
137	9 32	34.019	+ 5.93	19	17.18	+0.09	0.828	0.5074583	− 348	− 10	− 842	Not applied	− 492	− 39	0.5072852
139	10 32	34.469	5.93	20	17.34	0.09	0.828	0.5073596	348	11	850		502	39	0.5071846
138	11 30	32.981	5.93	19	17.42	0.09	0.826	0.5076970	348	10	854		472	39	0.5075247
140	12 31	34.812	5.93	19	17.43	0.09	0.826	0.5072861	348	10	854		501	39	0.5071109
													Mean	...	0.5072764
137	21 30	34.011	+ 5.93	18	17.31	0.00	0.827	0.5074602	− 348	− 9	− 848		− 491	− 39	0.5072867
139	22 32	34.461	5.93	18	17.34	0.00	0.827	0.5073612	348	9	850		501	39	0.5071865
138	23 32	32.971	5.93	19	17.33	0.00	0.827	0.5076991	348	10	849		473	39	0.5075272
140	0 31	34.804	5.93	18	17.33	0.00	0.825	0.5072878	348	9	849		500	39	0.5071133
													Mean	...	0.5072784
													Time of Vibration of Mean Pendulum	...	0.5072774
								30-31 March, 1906.							
140	9 25	34.804	+ 6.24	18	17.35	−0.07	0.823	0.5072878	− 366	− 9	− 850	Not applied	− 499	− 39	0.5071115
138	10 26	32.973	6.24	19	17.41	0.07	0.823	0.5076988	366	10	853		471	39	0.5075249
139	11 24	34.460	6.24	19	17.34	0.07	0.824	0.5073617	366	10	850		499	39	0.5071853
137	12 23	34.016	6.24	19	17.16	0.07	0.824	0.5074589	366	10	841		489	39	0.5072844
													Mean	...	0.5072765
140	21 31	34.794	+ 6.24	18	17.06	+0.05	0.825	0.5072900	− 366	− 9	− 836		− 500	− 39	0.5071150
138	22 33	32.962	6.24	18	17.10	0.05	0.825	0.5077011	366	9	838		472	39	0.5075287
139	23 30	34.449	6.24	19	17.14	0.05	0.825	0.5073641	366	10	840		500	39	0.5071886
137	0 34	34.001	6.24	19	17.20	0.05	0.825	0.5074625	366	10	843		490	39	0.5072877
													Mean	...	0.5072800
													Time of Vibration of Mean Pendulum	...	0.5072783
													General Mean	...	0.5072779
								Quetta.							
								3-4 April, 1906.							
	h m	s	s	′	°	°		s							s
137	9 57	34.009	+ 3.36	19	15.51	0.00	0.773	0.5074607	− 197	− 10	− 760	Not applied	− 459	− 43	0.5073138
139	10 57	34.458	3.36	20	15.49	0.00	0.773	0.5073622	197	11	759		468	43	0.5072144
138	11 50	32.967	3.36	20	15.50	0.00	0.773	0.5077001	197	11	760		442	43	0.5075548
140	12 46	34.800	3.36	19	15.49	0.00	0.773	0.5072885	197	10	759		468	43	0.5071408
													Mean	...	0.5073059
137	21 49	34.006	+ 3.36	19	15.37	+0.19	0.773	0.5074613	− 197	− 10	− 753		− 459	− 43	0.5073151
139	22 51	34.457	3.36	18	15.55	0.19	0.772	0.5073622	197	9	762		468	43	0.5072143
138	23 51	32.963	3.36	19	15.71	0.19	0.772	0.5077011	197	10	770		442	43	0.5075549
140	0 49	34.787	3.36	18	15.92	0.19	0.772	0.5072915	197	9	780		468	43	0.5071418
													Mean	...	0.5073065
													Time of Vibration of Mean Pendulum	...	0.5073062

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
								4·5 April, 1906.							
	h m	s	s	′	°	°		s							s
140	9 58	34·780	+ 3·86	19	15·99	0·00	0·770	0·5072929	− 227	− 10	− 784	Not applied	− 467	− 43	0·5071398
138	10 56	32·947	3·86	20	16·02	0·00	0·770	0·5077049	227	11	785		440	43	0·5075543
139	11 54	34·432	3·86	19	16·01	0·00	0·769	0·5073678	227	10	784		466	43	0·5072148
137	12 51	33·985	3·86	19	16·00	0·00	0·769	0·5074661	227	10	784		457	43	0·5073140
													Mean	...	0·5073057
140	21 52	34·773	+ 3·86	18	16·23	+ 0·10	0·770	0·5072945	− 227	− 9	− 795		− 467	− 43	0·5071404
138	22 54	32·941	3·86	19	16·27	0·10	0·770	0·5077062	227	10	797		440	43	0·5075545
139	23 53	34·426	3·86	19	16·37	0·10	0·769	0·5073688	227	10	802		466	43	0·5072140
137	0 54	33·976	3·86	19	16·50	0·10	0·769	0·5074680	227	10	809		457	43	0·5073134
													Mean	...	0·5073056
													Time of Vibration of Mean Pendulum	...	**0·5073057**
								5·6 April, 1906.							
139	10 20	34·401	+ 4·30	19	16·77	− 0·06	0·767	0·5073745	− 252	− 10	− 822	Not applied	− 465	− 43	0·5072153
137	11 18	33·955	4·30	18	16·77	0·06	0·767	0·5074728	252	9	822		456	43	0·5073146
140	12 12	34·749	4·30	18	16·70	0·06	0·767	0·5072995	252	9	818		465	43	0·5071408
138	13 11	32·921	4·30	19	16·60	0·06	0·768	0·5077110	252	10	813		439	43	0·5075553
													Mean	...	0·5073065
139	22 24	34·395	+ 4·30	18	16·90	+ 0·16	0·768	0·5073758	− 252	− 9	− 828		− 465	− 43	0·5072161
137	23 25	33·950	4·30	19	17·08	0·16	0·767	0·5074740	252	10	837		456	43	0·5073142
140	0 24	34·741	4·30	19	17·21	0·16	0·766	0·5073011	252	10	843		464	43	0·5071399
138	1 22	32·907	4·30	19	17·38	0·16	0·765	0·5077143	252	10	852		438	43	0·5075548
													Mean	...	0·5073063
													Time of Vibration of Mean Pendulum	...	**0·5073064**
													General Mean	...	**0·5073061**
								Dehra Dun—*(Pendulum room)*.							
								21-22 April, 1906.							
	h m	s	s	′	°	°		s							s
137	11 56	33·708	+ 14·76	17	26·03	− 0·15	0·837	0·5075283	− 866	− 8	− 1275	Not applied	− 497	− 39	0·5072598
139	12 56	34·151	14·76	17	25·83	0·15	0·838	0·5074290	866	8	1266		508	39	0·5071603
138	13 55	32·693	14·76	18	25·71	0·15	0·838	0·5077656	866	9	1260		479	39	0·5075003
140	14 56	34·500	14·76	17	25·57	0·15	0·839	0·5073530	866	8	1253		508	39	0·5070856
													Mean	...	0·5072515
137	23 59	33·708	+ 14·76	16	25·81	+ 0·12	0·835	0·5075283	− 866	− 7	− 1265		− 496	− 39	0·5072610
139	0 59	34·150	14·76	19	25·97	0·12	0·834	0·5074292	866	10	1273		505	39	0·5071599
138	2 0	32·687	14·76	16	26·08	0·12	0·834	0·5077672	866	7	1278		477	39	0·5075005
140	3 0	34·483	14·76	17	26·17	0·12	0·833	0·5073568	866	8	1282		505	39	0·5070868
													Mean	...	0·5072521
													Time of Vibration of Mean Pendulum	...	**0·5072518**
								22-23 April, 1906.							
140	11 52	34·473	+ 15·10	17	26·18	− 0·09	0·836	0·5073587	− 886	− 8	− 1283	Not applied	− 507	− 39	0·5070864
138	12 52	32·679	15·10	18	25·92	0·09	0·837	0·5077691	886	9	1270		479	39	0·5075008
139	13 51	34·143	15·10	16	25·88	0·09	0·837	0·5074309	886	7	1268		507	39	0·5071602
137	14 51	33·707	15·10	17	25·85	0·09	0·835	0·5075286	886	8	1267		496	39	0·5072590
													Mean	...	0·5072516
140	0 13	34·484	+ 15·10	17	26·03	+ 0·11	0·834	0·5073563	− 886	− 8	− 1275		− 505	− 39	0·5070850
138	1 12	32·682	15·10	17	26·18	0·11	0·834	0·5077683	886	8	1283		477	39	0·5074990
139	2 13	34·140	15·10	17	26·29	0·11	0·834	0·5074316	886	8	1288		505	39	0·5071590
137	3 12	33·695	15·10	18	26·37	0·11	0·832	0·5075312	886	9	1292		494	39	0·5072592
													Mean	...	0·5072506
													Time of Vibration of Mean Pendulum	...	**0·5072511**

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
								23-24 April, 1906.							
	h m	s	s	′	°	°		s							s
139	12 9	34·128	+15·10	17	26·52	−0·16	0·833	0·5074343	−886	−8	−1299	Not applied	−505	−39	0·5071606
137	13 9	33·688	15·10	16	26·40	0·16	0·833	0·5075328	886	7	1294		495	39	0·5072607
140	14 9	34·468	15·10	18	26·20	0·16	0·834	0·5073598	886	9	1284		505	39	0·5070875
138	15 8	32·676	15·10	17	26·10	0·16	0·834	0·5077697	886	8	1279		477	39	0·5075008
													Mean	...	0·5072524
139	0 14	34·140	+15·10	17	26·15	+0·14	0·834	0·5074316	−886	−8	−1281		−505	−39	0·5071597
137	1 12	33·699	15·10	18	26·29	0·14	0·834	0·5075303	886	9	1288		495	39	0·5072586
140	2 7	34·477	15·10	18	26·43	0·14	0·832	0·5073578	886	9	1295		504	39	0·5070845
138	3 13	32·676	15·10	17	26·55	0·14	0·832	0·5077697	886	8	1301		476	39	0·5074987
													Mean	...	0·5072504
										Time of Vibration of Mean Pendulum				...	0·5072514
								24-25 April, 1906.							
138	12 11	32·661	+15·27	17	26·85	−0·05	0·832	0·5077735	−896	−8	−1316	Not applied	−476	−39	0·5075000
140	13 12	34·455	15·27	16	26·81	0·05	0·834	0·5073627	896	7	1314		505	39	0·5070866
137	14 8	33·676	15·27	17	26·77	0·05	0·832	0·5075356	896	8	1312		494	39	0·5072607
139	15 6	34·123	15·27	17	26·69	0·05	0·833	0·5074353	896	8	1308		505	39	0·5071597
													Mean	...	0·5072517
138	0 17	32·661	+15·27	16	26·68	+0·08	0·833	0·5077736	−896	−7	−1307		−476	−39	0·5075011
140	1 20	34·460	15·27	17	26·80	0·08	0·832	0·5073617	896	8	1313		504	39	0·5070857
137	2 18	33·680	15·27	17	26·86	0·08	0·832	0·5075347	896	8	1316		494	39	0·5072594
139	3 16	34·117	15·27	18	26·92	0·08	0·832	0·5074367	896	9	1319		504	39	0·5071600
													Mean	...	0·5072516
										Time of Vibration of Mean Pendulum				...	0·5072516
													General Mean	...	0·5072515

TIME OF VIBRATION AT DEHRA DUN.

In Table II the times of vibration of each pendulum in November and April respectively are collected.

Table II.—Times of Vibration at Dehra Dún.

Date	137	138	139	140	Mean
			November 1905.		
	s	s	s	s	s
Nov. 12—13	0·5072577	0·5074989	0·5071600	0·5070856	0·5072505
" 13—14	2577	4981	1590	0849	2499
" 14—15	2596	5001	1603	0857	2514
Mean	0·5072583	0·5074990	0·5071598	0·5070854	0·5072506
			April 1906.		
April 21—22	0·5072604	0·5075004	0·5071601	0·5070862	0·5072518
" 22—23	2591	4999	1596	0857	2511
" 23—24	2597	4997	1602	0860	2514
" 24—25	2601	5005	1598	0862	2516
Mean	0·5072598	0·5075001	0·5071599	0·5070860	0·5072515
Change, April-Nov.	+ 15	+ 11	+ 1	+ 6	+ 9

The agreement between the November and April values is more satisfactory than in the preceding season; it will nevertheless be desirable to examine the differences between the individual pendulums and the mean pendulum in the same way as was done in Table III of Chap. III.

These differences are shewn in Table III for each set, and in Table IV the means for each station are given.

Table III.—Differences between Individual Pendulums and Mean Pendulum.

Station	Date	137	v	138	v	139	v	140	v
	1905-06								
Dehra Dun ...	Nov. 12-13	− 72	+ 7	− 2484	+ 4	+ 905	− 6	+ 1649	− 6
	„ 13-14	78	1	2482	6	909	2	1650	5
	„ 14-15	82	− 3	2487	1	911	0	1657	+ 2
Simla ...	Dec. 15-16	74	+ 5	2487	+ 1	906	− 5	1655	0
	„ 16-17	78	1	2488	0	908	3	1657	+ 2
	„ 17-18	78	1	2490	− 2	909	2	1659	4
Kálka ...	Dec. 22-23	81	− 2	2500	− 12	925	+ 14	1656	+ 1
Ludhiána ...	Dec. 30-31	81	− 2	2489	− 1	908	− 3	1662	+ 7
	„ 31-Jan. 1	69	+ 10	2495	7	907	4	1656	1
	Jan. 2- 3	77	2	2489	1	904	7	1662	7
	„ 3- 4	67	12	2491	3	905	6	1653	− 2
Mian Mir ...	Jan. 10-11	66	+ 13	2495	− 7	908	− 3	1654	− 1
	„ 11-12	81	− 2	2489	1	007	4	1664	+ 9
	„ 12-13	77	+ 2	2494	6	909	2	1661	6
Ferozepore ...	Jan. 17-18	68	+ 11	2497	− 9	912	+ 1	1652	− 3
	„ 18-19	78	1	2488	0	909	− 2	1657	+ 2
	„ 20-21	77	2	2490	− 2	907	4	1660	5
Pathánkot ...	Feb. 2- 3	82	− 3	2484	+ 4	914	+ 3	1651	− 4
	„ 3- 4	68	+ 11	2493	− 5	907	− 4	1655	0
	„ 4- 5	81	− 2	2478	+ 10	907	4	1650	− 5
Montgomery ...	Feb. 17-18	92	− 13	2477	+ 11	911	0	1659	+ 4
	„ 18-19	70	+ 9	2495	− 7	917	+ 6	1647	− 8
	„ 19-20	78	1	2489	1	910	− 1	1657	+ 2
Dera Gházi Khan ...	Feb. 27-28	75	+ 4	2493	− 5	914	+ 3	1652	− 3
	„ 28-Mar. 1	86	− 7	2484	+ 4	914	3	1654	1
	Mar. 1- 2	81	2	2485	3	908	− 3	1656	+ 1
Multán ...	Mar. 7- 8	76	+ 3	2491	− 3	919	+ 8	1649	− 6
	„ 8- 9	78	1	2496	8	915	4	1658	+ 3
	„ 9-10	84	− 5	2485	+ 3	918	7	1653	− 2
Jacobabad ...	Mar. 15-16	84	− 5	2490	− 2	915	+ 4	1657	+ 2
	„ 16-17	80	1	2480	+ 8	892	− 19	1668	13
	„ 17-18	77	+ 2	2487	1	912	+ 1	1653	− 2
Sibi ...	Mar. 21-22	80	− 1	2489	− 1	914	+ 3	1656	+ 1
	„ 22-23	84	5	2488	0	915	4	1656	1
	„ 23-24	79	0	2488	0	916	5	1651	− 4
	„ 24-25	80	− 1	2488	0	914	3	1653	2
	„ 25-26	82	3	2486	+ 2	909	− 2	1660	+ 5
Mach ...	Mar. 29-30	86	− 7	2485	+ 3	918	+ 7	1653	− 2
	„ 30-31	78	+ 1	2485	3	914	3	1650	5
Quetta ...	Ap. 3- 4	83	− 4	2486	+ 2	918	+ 7	1649	− 6
	„ 4- 5	80	1	2487	1	913	2	1656	+ 1
	„ 5- 6	80	1	2487	1	907	− 4	1661	6
Dehra Dun ...	Ap. 21-22	86	− 7	2486	+ 2	917	+ 6	1656	+ 1
	„ 22-23	80	1	2488	0	915	4	1654	− 1
	„ 23-24	83	4	2483	+ 5	912	1	1654	1
	„ 24-25	85	6	2489	− 1	918	7	1654	1
Mean		**79**	...	**2488**	...	**911**	...	**1655**	...

Table IV.—Differences between Individual Pendulums and Mean Pendulum.

Station	Date	137	v	138	v	139	v	140	v
Dehra Dun ...	1905-06 Nov. 12-15	− 77	+ 2	− 2484	+ 4	+ 908	− 4	+ 1652	− 3
Simla ...	Dec. 15-18	77	2	2488	0	908	4	1657	+ 2
Kálka ...	" 22-23	81	− 2	2500	− 12	925	+ 13	1656	1
Ludhiána ...	" 30-Jan. 4	73	+ 6	2491	3	906	− 6	1659	4
Mian Mir ...	Jan. 10-13	75	4	2493	5	908	4	1659	4
Ferozepore ...	" 17-21	75	4	2492	4	909	3	1656	1
Pathánkot ...	Feb. 2- 5	77	2	2485	+ 3	909	3	1652	− 3
Montgomery ...	" 17-20	80	− 1	2487	1	913	+ 1	1654	1
Dera Gházi Khan ...	" 27-Mar. 2	81	2	2487	1	912	0	1654	1
Multán ...	March 7-10	79	0	2491	− 3	917	+ 5	1653	2
Jacobabad ...	" 15-18	80	1	2485	+ 3	907	− 5	1660	+ 5
Sibi ...	" 21-26	81	2	2488	0	915	+ 3	1655	0
Mach ...	" 29-31	82	3	2484	+ 4	916	4	1652	− 3
Quetta ...	April 3- 6	81	2	2487	1	913	+ 1	1655	0
Dehra Dun ...	" 21-25	83	4	2486	2	916	+ 4	1655	0
	Mean ...	79	...	2488	...	912	...	1655	...

There is no evidence of any pendulum having changed its length appreciably with reference to the mean, and a simple mean of the times of vibration at Dehra Dun, in November and April respectively, will be used for the deduction of g.

In the following table the times of vibration of each pendulum and of the mean pendulum are shewn, together with the differences from Dehra Dun and the resulting values of g. The value of g at Dehra Dun has been taken to be 979·063.

Table V.—Mean Times of Vibration and Deduced Values of g.

Station		137	138	139	140	Mean
Dehra Dun	s.	0·5072591	0·5074996	0·5071599	0·5070857	0·5072511
Simla	s.	0·5073165	0·5075576	0·5072180	0·5071431	0·5073088
		+ 574	+ 580	+ 581	+ 574	+ 577
	g.	978·842	978·839	978·838	978·841	978·840
Kálka	s.	0·5072373	0·5074792	0·5071367	0·5070636	0·5072292
		− 218	− 204	− 232	− 221	− 219
	g.	979·147	979·141	979·152	979·149	979·147
Ludhiána	s.	0·5072038	0·5074456	0·5071059	0·5070306	0·5071965
		− 553	− 540	− 540	− 551	− 546
	g.	979·277	979·271	979·271	979·276	979·274
Mian Mir	s.	0·5071756	0·5074174	0·5070773	0·5070022	0·5071681
		− 835	− 822	− 826	− 835	− 830
	g.	979·384	979·380	979·382	979·385	979·383
Ferozepore	s.	0·5071866	0·5074283	0·5070882	0·5070135	0·5071791
		− 725	− 713	− 717	− 722	− 720
	g.	979·343	979·338	979·340	979·342	979·341
Pathánkot	s.	0·5072138	0·5074546	0·5071152	0·5070409	0·5072061
		− 453	− 450	− 447	− 448	− 450
	g.	979·238	979·236	979·235	979·236	979·237
Montgomery	s.	0·5071923	0·5074330	0·5070930	0·5070189	0·5071843
		− 668	− 666	− 669	− 668	− 668
	g.	979·321	979·320	979·321	979·321	979·321
Dera Gházi Khan	s.	0·5072258	0·5074664	0·5071265	0·5070523	0·5072177
		− 333	− 332	− 334	− 334	− 334
	g.	979·191	979·191	979·192	979·192	979·192
Multán	s.	0·5072124	0·5074536	0·5071128	0·5070392	0·5072045
		− 467	− 460	− 471	− 465	− 466
	g.	979·244	979·240	979·245	979·242	979·243
Jacobabad	s.	0·5072272	0·5074677	0·5071285	0·5070532	0·5072192
		− 319	− 319	− 314	− 325	− 319
	g.	979·186	979·186	979·184	979·188	979·186
Sibi	s.	0·5072448	0·5074855	0·5071452	0·5070712	0·5072367
		− 143	− 141	− 147	− 145	− 144
	g.	979·118	979·117	979·119	979·119	979·119
Mach	s.	0·5072861	0·5075263	0·5071863	0·5071127	0·5072779
		+ 270	+ 267	+ 264	+ 270	+ 268
	g.	978·959	978·959	978·961	978·959	978·960
Quetta	s.	0·5073142	0·5075548	0·5072148	0·5071406	0·5073061
		+ 551	+ 553	+ 549	+ 549	+ 550
	g.	978·851	978·850	978·851	978·851	978·851

The Reduction to Sea-level.

Orographical corrections were required for six of the stations of this season, namely for Simla, Kálka, Pathánkot, Sibi, Mach and Quetta. A different method of analysing the masses lying in the several zones was employed this year. Hitherto the zones have been cut up into more or less numerous compartments or blocks and an estimate has been made of the mean height of each block, that is to say of the height it would have if it were levelled.

By this process it was frequently necessary to imagine tremendous changes of level to take place, for a block might, and often did, contain both a lofty peak and a deep valley; I have shewn in Chapter II that all such imaginary levellings introduce error, and it was to avoid large operations of this kind that I altered the method.

Movements of masses in azimuth have, as has been pointed out, no effect on the vertical component of their attraction; if therefore a zone be divided up by contours and we measure the areas of all parts lying between the different pairs of contours, we shall be able to ascertain what fraction of the whole zone lies for instance, between 100 feet and 200 feet, 200 feet and 300 feet etc. etc. above or below the pendulum station. In this way we can collect areas of similar height in a more efficient way than by grouping blocks together as has been done hitherto. In fact by this method the zone is broken up into its component parts along natural lines, instead of by means of arbitrarily drawn radii.

It may be said that this plan can only be followed if contoured maps are available, but even if only hill-shaded maps can be had it is not more difficult to draw in approximate contours, at wide intervals, by eye than it is to estimate the mean heights of blocks; indeed in complicated country it is generally necessary to put in some contour lines before any estimate can be made. The new method has also a practical advantage in that by it only a limited number of different heights in each zone have to be dealt with: by the former method each block was likely to have a different height, so that in order to curtail the computation it was necessary to adopt some expedient involving a loss of accuracy. The advantage gained will be seen by comparing the tables of this year's computations with those of Chapter II.

Several methods of measuring the areas were tried, the one which I found most satisfactory was to draw radial lines at 5° intervals and then measure the total length of line intercepted between each pair of contours; in complicated country it proved very advantageous to draw the contours in different coloured inks so that each was instantly recognisable.

The intervals at which the contours should be drawn depend firstly on the distance of the area under consideration from the station. Up to half a mile 100 feet contours are desirable, thence up to 1 mile 200 feet, from 1 to 5 miles 500 feet, from 5 to 10 miles 1000 feet and from 10 miles to 35 miles 2000 feet. But this general rule may be modified according to the nature of the country and the kind of map that is available. In hilly country I like to have a special map on a scale of 12 inches to 1 mile for the immediate surroundings, that is to say up to a radius of about half a mile, a 4-inch to a mile map up to 2 miles, a 1-inch map to 10 miles and thence a quarter-inch map, but it is very seldom that all these are obtainable.

The following tables contain the details of all the stations considered. Hitherto the differences between the heights of the compartments and that of the station have been given in the tables, but I have preferred in this chapter to give the actual heights of the parts into which the zones have been divided.

Table VI.—Orographical Correction at Simla.

Height 7043 feet.

No. of Zone	1	2	3	4	5	6	7
Inner radius Outer radius	100 feet 200 „	200 feet 400 „	400 feet 600 „	600 feet 1000 „	1000 feet 1500 „	1500 feet 2000 „	2000 feet 2640 „
Height	*Fraction*	*Fraction*	*Fraction*	*Fraction*	*Fraction*	*Fraction*	*Fraction*
feet 5950							0·028
6050							·054
6150						0·023	·117
6250						·100	·130
6350					0·129	·122	·087
6450				0·027	·183	·098	·079
6550				·184	·118	·131	·092
6650			0·102	·352	·136	·110	·071
6750		0·036	·377	·147	·151	·137	·132
6850		·246	·260	·097	·111	·078	·077
6950		·597	·232	·149	·097	·095	·050
6980	0·60						
7000		·044	·029	·044			
7030	·40	·077			·056	·050	·041
7100							
7150					·019	·035	·028
7200						·021	·014
Effect	5·9	16·6	19·9	34·4	28·0	18·3	21·2

Table VI.—Orographical Correction at Simla—(Continued). *Height 7043 feet.*

No. of Zone	8	9	10	11	12	13	14
Inner radius Outer radius	½ mile ¾ ,,	¾ mile 1 ,,	1 mile 1½ ,,	1½ miles 2 ,,	2 miles 3 ,,	3 miles 4 ,,	4 miles 5 ,,
Height	*Fraction*	*Fraction*	*Fraction*	*Fraction*	*Fraction*	*Fraction*	*Fraction*
feet 4250							0·15
4750				0·02	0·05	0·20	·18
5250			0·13	·09	·22	·24	·18
5750	0·14	0·26	·23	·20	·32	·28	·17
6250	·44	·38	·22	·26	·30	·19	·12
6750	·36	·27	·23	·29	·05	·05	·06
7250	·06	·09	·14	·14	·06	·03	·09
7750			·05			·01	·05
Effect	30·9	21·0	30·2	14·1	26·5	19·2	14·7

No. of Zone	15	16	No. of Zone	17	18	19	20
Inner radius Outer radius	5 miles 7 ,,	7 miles 10 ,,	Inner radius Outer radius	10 miles 15 ,,	15 miles 20 ,,	20 miles 25 ,,	25 miles 35 ,,
Height	*Fraction*	*Fraction*	Height	*Fraction*	*Fraction*	*Fraction*	*Fraction*
feet 2500		0·04	*feet* 1000				0·02
3500	0·06	·19	2000	0·16	0·12	0·26	·39
4500	·38	·30	4000	·54	·44	·28	·16
5500	·30	·19	6000	·24	·34	·19	·21
6500	·15	·18	8000	·06	·10	·22	·18
7500	·08	·08	10000			·05	·04
8500	·03	·02					
Effect	21·1	22·6	Effect	28·6	11·9	9·4	13·2

Total effect of zones up to a radius of 35 miles = 407·7
Attraction ... = 407·7 × 0·000035 = 0·0143

For the region lying beyond the 35-mile radius we may assume that half is at a constant level of 1000 feet, and that the other half may be divided into 3 portions, namely a quadrant from north to east at an elevation of 10000 feet, a sector from north to 60° west of north at 6000 feet and a sector from east to 30° south of east also at 6000 feet.

The difference between the attraction of these masses and that of the infinite plain at the height of the station, outside the 35-mile radius, is

$$0 \cdot 000035 \left(\frac{1}{35 \times 5280}\right) \cdot \tfrac{1}{2} \cdot \left\{6000^2 \times \tfrac{1}{2} + 3000^2 \times \tfrac{1}{4} + 1000^2 \times \tfrac{1}{4}\right\}$$

$$= 0 \cdot 00194$$

The total orographical correction is therefore

$$0 \cdot 0143 + 0 \cdot 0019 = 0 \cdot 0162.$$

Table VII.—Orographical Correction at Kálka. Height 2202 feet.

No of Zone	1	2	3	No. of Zone	4	5	6	7
Inner Radius Outer Radius	1500 feet 2000 „	2000 feet 2640 „	½ mile ¾ „	Inner Radius Outer Radius	¾ mile 1 „	1 mile 2 miles	2 miles 3 „	3 miles 4 „
Height	*Fraction*	*Fraction*	*Fraction*	Height	*Fraction*	*Fraction*	*Fraction*	*Fraction*
feet				*feet* 1750			0·38	0·44
				1950	0·01			
				2000	·01	0·59		
2200	0·75	0·75	0·75	2200	·67		·09	·07
2400	·25		·13	2350	·03	·13	·11	·04
2525		·25		2450	·12			
2700			·12	2550	·09			
				2650	·07			
				2750		·21	·09	·06
				3500		·07	·25	·17
				4500			·08	·15
				5500				·07
Effect	0·75	1·50	2·31	Effect	0·99	9·92	15·19	14·86

Table VII.—Orographical Correction at Kálka—(Continued).

Height 2202 feet.

No. of Zone	8	9	10	No. of Zone	11	12	13	14
Inner Radius Outer Radius	4 miles 5 "	5 miles 7 "	7 miles 10 "	Inner Radius Outer Radius	10 miles 15 "	15 miles 20 "	20 miles 25 "	25 miles 35 "
Height	*Fraction*	*Fraction*	*Fraction*	Height	*Fraction*	*Fraction*	*Fraction*	*Fraction*
feet 1400		0·19	0·27	*feet* 900	0·16	0·28	0·32	0·38
1800	0·38	·31	·21	1200	·27	·17	·14	·11
2200	·17	·03	·05	1800	·05	·03	·05	·06
2800	·05	·07	·09	2600	·09	·12	·09	·10
3500	·19	·16	·16	4000	·33	·33	·21	·17
4500	·15	·20	·15	6000	·10	·07	·17	·10
5500	·06	·04	·07	8000			·02	·07
				10000				·01
Effect	8·8	10·7	8·4	Effect	9·6	4·4	4·3	6·0

Total effect of zones within 35-mile radius = 97·7

Attraction = 97·7 × 0·000035 = 0·0034

The outer zones may be divided into four sectors :—

Sector	Angle	Height
	°	*feet.*
1.	220	1000
2.	20	4000
3.	90	7000
4.	30	4000

The addition to the orographical correction on their account amounts to 0·0007.

The total orographical correction is therefore 0·0034 + 0·0007 = 0·0041.

Table VIII.—Orographical Correction at Pathánkot.

Height 1088 feet.

No. of Zone	1	2	3	4	5	6
Inner Radius Outer Radius	8 miles 12 „	12 miles 16 „	16 miles 20 „	20 miles 25 „	25 miles 30 „	30 miles 35 „
Height	*Fraction*	*Fraction*	*Fraction*	*Fraction*	*Fraction*	*Fraction*
feet 1100	0·85	0·75	0·66	0·65	0·62	0·60
2300	·15	·25				
3000			·32	·30	·15	·12
4000			·02			
5000				·13	·10	·11
7000				·02	·10	·12
9000					·03	·05
Effect	0·9	0·7	1·6	3·2	4·9	3·6

Total effect of zones within 35-mile radius = 14·9

Attraction = 14·9 × 0·000035 = 0·0005

Beyond the 35-mile radius the zones may be divided into 4 sectors:—

Sector	Angle	Height
	°	*feet.*
1.	180	1100
2.	45	5000
3.	90	8000
4.	45	3000

The addition to the orographical correction on account of the outer zones is therefore 0·0014

And the total orographical correction becomes 0·0005 + 0·0014 = 0·0019

Table IX.—Orographical Correction at Sibi.

Height 434 feet.

No. of Zone	1	2	3	4	5
Inner Radius Outer Radius	7 miles 10 „	10 miles 15 „	15 miles 20 „	20 miles 25 „	25 miles 35 „
Height	*Fraction*	*Fraction*	*Fraction*	*Fraction*	*Fraction*
feet 450	0·88	0·62	0·49	0·30	0·25
750	·12	·22	·25	·28	·12
1550		·16	·22	·34	·28
2250			·04		
2450				·08	·24
3550					·08
4450					·03
Effect	0	0·7	0·7	0·7	2·7

Total effect of zones within 35-mile radius = 4·8
Attraction = 4·8 × 0·000035 = 0·0002

The outer zones contain much higher hills and table-lands than come within the 35-mile circle. The region may be divided up into 4 sectors :—

Sector	Angle	Height
	°	*feet.*
1. From North to East,	90	4500
2. From East to S.E.,	45	2000
3. From S.E. to 30° W. of S.,	75	450
4. From 30° W. of S. to North,	150	5500

The attraction of the masses lying above the 450-foot plain outside the 35-mile circle is 0·0014

Hence the total orographical correction = 0·0014 + 0·0002 = 0·0016

Table X.—Orographical Correction at Mach.

Height 3522 feet.

No. of Zone	1	2	3	4	No. of Zone	5	6	7
Inner Radius Outer Radius	1000 feet 5280 „	1 mile 2 miles	2 miles 4 „	4 miles 7 „	Inner Radius Outer Radius	7 miles 10 „	10 miles 15 „	15 miles 20 „
Height	*Fraction*	*Fraction*	*Fraction*	*Fraction*	Height	*Fraction*	*Fraction*	*Fraction*
feet 2200				0·05	*feet* 1500	0·05	0·12	0·13
2700				·11	2700		·16	
2800				·07	2800	·22		·24
2900		0·13	0·16		4500	·24	·20	·09
3200		·45	·18		5800			·23
3300	0·5			·14	6000		·22	
3700	·5		·24		6500	·37	·21	·26
3800		·42			8000		·04	
4500				·20	8500	·12	·05	·05
4800			·30					
5700				·24				
6000			·12					
6800				·17				
7700				·02				
Effect	16·2	6·0	31·7	38·1	Effect	28·0	19·1	8·9

Table X.—Orographical Correction at Mach.—(Continued).

Height 3522 feet.

No. of Zone	8	9	10
Inner Radius Outer Radius	20 miles 25 „	25 miles 30 „	30 miles 35 „
Height	*Fraction*	*Fraction*	*Fraction*
feet 800	0·03	0·13	0·14
1500	·17	·09	·11
2700	·19	·12	·06
4500	·06	·13	·16
5200	...	·04	·13
6200	·39	·33	·28
8000	·03	·12	·10
8500	·11	...	...
10000	·02	·04	·02
Effect	7·7	5·4	2·6

Total effect of zones within 35-mile radius = 163·7
Attraction = 163·7 × 0·000035 = 0·0057

The region lying beyond the 35-mile circle may be divided into six sectors :—

Sector		Angle	Height
		°	*feet*
1.	N. to N. E. .	45	6000
2.	N. E. to 35° S. of E.	80	3000
3.	35° S. of E. to S.	55	300
4.	S. to S. W.	45	6000
5.	S. W. to W.	45	4000
6.	W. to N.	90	5000

The orographical correction on account of the outer zones is
0·00036

And the total orographical correction is 0·0057 + ·0004 = 0·0061

Table XI.—Orographical Correction at Quetta.
Height 5520 feet.

No. of Zone	1	2	3	4	5	6
Inner Radius Outer Radius	2 miles 3 „	3 miles 4 „	4 miles 5 „	5 miles 6 „	6 miles 7 „	7 miles 10 „
Height	*Fraction*	*Fraction*	*Fraction*	*Fraction*	*Fraction*	*Fraction*
feet 5500	0·89	0·76	0·51	0·28	0·31	0·16
5800	...	·08	·12	·21	·15	...
6300	...	...	...	...	...	·59
6500	0·11	·07	·19	·22	·28	...
7500	...	·07	·12	·16	·14	...
8000	...	...	...	...	...	·25
8500	...	·02	·06	·13	·12	...
Effect	1·7	4·2	5·8	6·4	4·4	7·9

No. of Zone	7	8	9	10	11
Inner Radius Outer Radius	10 miles 15 „	15 miles 20 „	20 miles 25 „	25 miles 30 „	30 miles 35 „
Height	*Fraction*	*Fraction*	*Fraction*	*Fraction*	*Fraction*
feet 2500	...	...	...	...	0·08
4500	...	...	0·03	0·07	·12
5500	0·27	0·30	·49	·49	·42
6200	·50	·43	·33	·35	·27
8000	·20	·19	·13	·09	·11
10000	·03	·08	·02	...	...
Effect	6·6	4·9	1·3	0·5	0·6

Total effect of zones within 35-mile radius = 44·3
Attraction = 44·3 × 0·000035 = 0·0016

The regions beyond the 35-mile circle may be divided into six sectors as follows :—

	Sector	Angle	Height
		°	*feet*
1.	N. to N. E.	45	5000
2.	N. E. to E.	45	6000
3.	E. to 30° S. of E.	30	2500
4.	30° S. of E. to 10° E. of S.	50	300
5.	10° E. of S. to 50° W. of S.	60	6000
6.	50° W. of S. to N.	130	3500

The addition to the orographical correction on account of the outer regions is

$$0 \cdot 0006$$

Hence the total orographical correction is

$$0 \cdot 0016 + 0 \cdot 0006 = 0 \cdot 0022$$

In Table XII the results of the season's work are collected and the values of g_0'' and γ_0 computed and compared; γ_0 has, as before, been derived from Helmert's formula of 1884, namely,

$$\gamma_0 = 978{\cdot}00\ (1 + 0{\cdot}005310 \sin^2 \phi)$$

where ϕ is the latitude of the station of observation.

Table XII.—Abstract of Final Results.

Station	Latitude	Height	Observed g	$g\frac{2h}{R}$	$g\frac{3}{4}\frac{h}{R}$	O	Value at sea level g_0''	γ_0	$g_0'' - \gamma_0$
	° ′ ″	feet							
Simla ...	31 6 19	7043	978·840	+0·657	−0·246	+0·016	979·267	979·386	−0·119
Kálka ...	30 50 8	2202	979·147	+0·205	−0·077	+0·004	979·279	979·364	−0·085
Ludhiána ...	30 55 25	835	979·274	+0·078	−0·029	0·00	979·323	979·371	−0·048
Mian Mir ...	31 31 37	708	979·383	+0·066	−0·025	0·00	979·424	979·420	+0·004
Ferozepore ...	30 55 48	647	979·341	+0·060	−0·023	0·00	979·378	979·372	+0·006
Pathánkot ...	32 16 33	1088	979·237	+0·101	−0·038	+0·002	979·302	979·481	−0·179
Montgomery ...	30 39 47	557	979·321	+0·052	−0·019	0·00	979·354	979·351	+0·003
Dera Gházi Khan	30 3 49	397	979·192	+0·037	−0·014	0·00	979·215	979·303	−0·088
Multán ...	30 11 11	404	979·243	+0·038	−0·014	0·00	979·267	979·312	−0·045
Jacobabad ...	28 16 34	183	979·186	+0·017	−0·006	0·00	979·197	979·166	+0·031
Sibi ...	29 32 46	434	979·119	+0·040	−0·015	+0·002	979·146	979·262	−0·116
Mach ...	29 52 25	3522	978·960	+0·328	−0·123	+0·006	979·171	979·288	−0·117
Quetta ...	30 12 15	5520	978·851	+0·515	−0·193	+0·002	979·175	979·314	−0·139

The difference between g at Dehra Dún and g at Mian Mir is by these observations

$$(979{\cdot}063 - 979{\cdot}383) = -0{\cdot}320$$

On p. [120] of Volume V. *Op. G. T. S.* we find Basevi's Vibration Numbers to have been

At Dehra Dún	86020·86
At Mian Mir	86034·55
Difference = −	13·69

$$\text{Now } dg = \frac{2g}{N}\, dN$$

$$= \frac{2 \times 979{\cdot}063}{86021} \times 13{\cdot}69$$

$$= 0{\cdot}311$$

Hence the difference between the new result and the old is 0·009, which is not very large. It does not appear therefore that the special stand used by Basevi at Mian Mir and Moré introduced any large error.

CHAPTER V.

The Operations in 1906-07.

The object of the observations undertaken in 1906-07 was the examination in greater detail of the variation in the force of gravity at the foot of the Himalayas and in the neighbourhood of the Siwálik range.

The information on this subject obtained by the work of the former seasons consists of four facts, namely the values of the quantity $(g_0''-\gamma_0)$ at Pathánkot, Kálka, Dehra Dún and Siliguri.

Pathánkot is situated about 8 miles from the Siwáliks and 16 miles from the Himalayas, but the two ranges are not clearly divided in this locality, the topography being confused and difficult. The value of $(g_0''-\gamma_0)$ is here $-0{\cdot}179$.

At Kálka which is at the foot of the Himalayas, with the Siwáliks lying 2 miles to the south-west, $g_0''-\gamma_0 = -0{\cdot}085$.

At Dehra Dún which lies about half way between the Siwáliks and the Himalayas at a point where they are quite distinct and separated by about 10 miles, $g_0''-\gamma_0 = -0{\cdot}126$; and at Siliguri situated about 7 miles from the Himalayas at a place where the Siwáliks are merged in their great neighbour, $g_0''-\gamma_0 = -0{\cdot}137$.

Our present information then shows that the deficiency in gravity is by no means constant, but we do not know whether the variations are strictly local in character or whether they are rather to be classed as regional.

The pendulum stations of 1906-07 were chosen with a view to gaining more knowledge of these variations.

The stations selected may be divided into four classes, namely,

1.	At the foot of the Himalayas, ...	Rájpur, Kálsi
2.	Midway between the Himalayas and Siwáliks, ...	Fatehpur.
3.	In the Siwáliks, ...	Hardwár, Mohan, Asarori
4.	Outside the Siwáliks but not far from them, ...	Roorkee, Nojli

Another important object is the location of the position of the line where the excess of the observed over the computed force of gravity attains a maximum.

The existence of such a line, running more or less parallel to the Himalayas, and about 130 miles from them, was deduced from the latitude observations by Colonel Burrard in *Professional Paper No. 5*, and the lines of pendulum observations of 1904-05 and 1905-06 crossed it near Kisnapur, and between Montgomery and Mián Mir, respectively. Three more stations, extending southwards along the Great Arc of Meridian from Nojli, were therefore added to the programme. Kaliána, which was Basevi's Base station, was the most northerly of the three, the others being Meerut and Gesupur.

The descriptions of the stations are given in the order in which they were visited.

THE STATIONS.

Hardwar.

		°	′	″
Latitude	... ...	29	56	29
Longitude	... ...	78	9	19
Height above mean sea level ...			949 feet	

The pendulum station was in a small canal bungalow on the right bank of the Ganges Canal about 200 yards below the Mayapur Bridge.

The height was determined by levelling from a bench-mark on the bridge.

Roorkee.

		°	′	″
Latitude	... ...	29	52	20
Longitude	... ...	77	53	59
Height above mean sea level ...			867 feet	

The pendulum station was in a large room at the N. E. corner of P. W. D. Inspection House, generally called the Malakpur Bungalow.

The height was determined by levelling from nearest bench-mark on the bank of the Ganges Canal.

The room was a very good one with a steady temperature and a thick floor.

Nojli.

		°	′	″
Latitude	... ...	29	53	28
Longitude	... ...	77	40	25
Height above mean sea level ...			879 feet	

The pendulums were swung in the ground floor room of Nojli Tower Station of the G. T. Survey. The space afforded by the room was scarcely sufficient and the temperature was difficult to control. The height given is that derived from the Principal Triangulation.

Kaliana.

		°	′	″
Latitude	... ...	29	30	55
Longitude	... ...	77	39	6
Height above mean sea level ...			810 feet	

The pendulums were swung in the east room of the observatory built in 1836 by Major, afterwards Sir George Everest. In this room the Invariable Pendulums were swung by Basevi in January 1866, in May of the same year, and in April 1870; also by Heaviside in January 1873. The Russian Reversible Pendulums were swung in the same room by Heaviside in February 1873. The observatory is a station of the Principal Triangulation and the height given is that derived from the vertical angles.

As this station is of exceptional importance 5 complete sets of observations were made here.

Meerut.

	°	′	″
Latitude	29	0	26
Longitude	77	41	40
Height above mean sea level ...		734 feet	

The pendulum station was in the south-western room of Bungalow No. 163, which is the last house but one from the western end of the Mall, on the south side.

The height was determined by levelling from a bench-mark of the G. T. Survey on the Church steps.

The observations at Meerut were spread over a period of nearly a month. This was done for reasons unconnected with the pendulum work; it has the effect of rendering the three determinations more independent of each other than is usually the case.

Gesupur.

	°	′	″
Latitude	28	33	2
Longitude	77	42	3
Height above mean sea level ...		691 feet	

The pendulums were swung in the north-western room of the bungalow belonging to the Irrigation Department on the left bank of the Ganges Canal near the village of Gesupur.

The height was determined by levelling from a canal bench-mark on the plinth of the milestone marked "120 miles from Maiapur".

Mohan.

	°	′	″
Latitude	30	10	53
Longitude	77	54	37
Height above mean sea level ...		1660 feet	

The pendulum station was in the eastern of the two larger rooms of the Forest Rest-house, which stands on a spur of the Siwáliks on the western side of the main road from Sahápanpur to Rájpur.

The height was determined by levelling from the Mohan Bench-mark of the G. T. Survey. At this and the subsequent stations only two complete sets of observations were made.

Asarori.

	°	′	″
Latitude	30	14	25
Longitude	77	58	3
Height above mean sea level ...		2467 feet	

The pendulums were swung in the largest room of the P. W. D. Rest-house which stands on the western side of the Saháranpur-Rájpur road, a little less than 14 miles from Rájpur.

The height was determined by levelling from the Mohobawála Bench-mark of the G. T. Survey. At the close of the second set of swings stars could not be obtained and continuity was carried on to the next night by swinging two pendulums at night and the other two at the corresponding hours next morning.

Dehra Dún was visited and one set of observations made on the way from Asarori to Fatehpur.

Fatehpur.

		°	′	″
Latitude	... ...	30	25	53
Longitude	... ...	77	43	37
Height above mean sea level ...			1434 feet	

The pendulums were swung in the northernmost of the three large rooms of the Military Works Service Inspection Bungalow.

There is a secondary triangulation station on the roof of this bungalow and the co-ordinates given are those of this station, the height being reduced to floor level.

Kalsi.

		°	′	″
Latitude	... ...	30	31	8
Longitude	... ...	77	50	26
Height above mean sea level ...			1684 feet	

The pendulum station was in a bungalow belonging to the Military Works Service, which stands about 150 yards east of the Inspection Bungalow. The latter is commonly called the Kálsi Bungalow, but it should more properly be called the Haripur Bungalow, for the large village of Kálsi is about 2 miles further up the Chakrata road.

The height was determined by levelling from the site of an old station of the triangulation, called 'Gular Ghat'. The station had been washed away by the Jumna some years before but it was possible to identify its position with fair accuracy. The height given above may very possibly be in error by 5 feet, but is not likely to be 10 feet from the truth.

Rajpur.

		°	′	″
Latitude	... ...	30	24	12
Longitude	... ...	78	5	47
Height above mean sea level ...			3321 feet	

The pendulums were swung in a room lent by the Himalaya Glass Works. The room was one of those on the northern side of the main building which stands about 100 yards south of the public road.

The height was determined by levelling from a bench-mark of the G. T. Survey on the plinth of a house in Rájpur about 250 yards east of the pendulum room.

From Rájpur the pendulums were brought back to Dehra Dún and three complete sets of observations were made with them there.

The set made between the observations at Asarori and Fatehpur has been included with these three in deducing the values of the time of vibration closing.

The results of the determinations of the flexure correction at each station are given in Table I.

Table I. Flexure Correction.

Station	Date	Observed Correction	Adopted Correction
Dehra Dún	1906 Nov. 26th 30th	$^{s}47{\cdot}6 \times 10^{-7}$ $48{\cdot}2$ $46{\cdot}9$ $45{\cdot}6$	$^{s}- 47 \times 10^{-7}$
Hardwár ...	Dec. 5th 10th 11th	$^{s}64{\cdot}4 \times 10^{-7}$ $65{\cdot}3$ $63{\cdot}9$ $62{\cdot}5$ $63{\cdot}0$ $63{\cdot}6$ $63{\cdot}1$	$^{s}- 64 \times 10^{-7}$
Roorkee ...	Dec. 15th 16th 21st	$^{s}42{\cdot}8 \times 10^{-7}$ $43{\cdot}5$ $42{\cdot}8$ $42{\cdot}8$ $41{\cdot}9$	$^{s}- 43 \times 10^{-7}$
Nojli ...	Dec. 26th 29th	$^{s}59{\cdot}6 \times 10^{-7}$ $59{\cdot}2$ $58{\cdot}5$ $58{\cdot}4$	$^{s}- 59 \times 10^{-7}$
Kaliána ...	1907 Jan. 4th 6th	$^{s}86{\cdot}2 \times 10^{-7}$ $84{\cdot}2$ $82{\cdot}1$ $82{\cdot}9$ $79{\cdot}8$ $82{\cdot}0$	4th to 6th $^{s}- 83 \times 10^{-7}$
	Jan. 11th 12th	$^{s}75{\cdot}9 \times 10^{-7}$ $77{\cdot}7$ $79{\cdot}3$ $79{\cdot}9$	8th to 11th $^{s}- 78 \times 10^{-7}$
Meerut ...	Jan. 31st Feb. 2nd	$^{s}46{\cdot}2 \times 10^{-7}$ $47{\cdot}1$ $45{\cdot}5$ $46{\cdot}2$	31st Jan. to 2nd Feb. $^{s}- 46 \times 10^{-7}$
	Feb. 18th 24th 26th	$^{s}42{\cdot}9 \times 10^{-7}$ $43{\cdot}3$ $43{\cdot}8$ $41{\cdot}9$ $43{\cdot}6$	18th to 26th $^{s}- 43 \times 10^{-7}$

Station	Date	Observed Correction	Adopted Correction
Gesupur ...	Mar. 3rd 6th	$^{s}42{\cdot}4 \times 10^{-7}$ $42{\cdot}5$ $41{\cdot}6$ $42{\cdot}5$	$^{s}- 42 \times 10^{-7}$
Mohan ...	Mar. 15th 18th	$^{s}73{\cdot}7 \times 10^{-7}$ $72{\cdot}1$ $71{\cdot}9$ $68{\cdot}5$ $70{\cdot}0$	$^{s}- 71 \times 10^{-7}$
Asarori ...	Mar. 24th 27th	$^{s}49{\cdot}2 \times 10^{-7}$ $50{\cdot}2$ $49{\cdot}1$ $49{\cdot}9$	$^{s}- 50 \times 10^{-7}$
Fatehpur ...	Ap. 4th 7th	$^{s}68{\cdot}1 \times 10^{-7}$ $65{\cdot}4$ $67{\cdot}9$ $64{\cdot}8$ $65{\cdot}3$ $65{\cdot}4$ $65{\cdot}3$	$^{s}- 66 \times 10^{-7}$
Kálsi ...	Ap. 9th 12th	$^{s}69{\cdot}8 \times 10^{-7}$ $69{\cdot}7$ $70{\cdot}7$ $69{\cdot}0$ $68{\cdot}3$ $68{\cdot}6$	$^{s}- 69 \times 10^{-7}$
Rájpur ...	Ap. 16th 18th 20th	$^{s}55{\cdot}4 \times 10^{-7}$ $55{\cdot}1$ $55{\cdot}6$ $53{\cdot}4$ $53{\cdot}0$	$^{s}- 55 \times 10^{-7}$
Dehra Dún	Mar. 29th Ap. 1st	$^{s}49{\cdot}6 \times 10^{-7}$ $49{\cdot}1$ $49{\cdot}2$	29th to 30th Mar. $^{s}- 49 \times 10^{-7}$
	Ap. 22nd 27th 28th	$^{s}40{\cdot}3 \times 10^{-7}$ $37{\cdot}8$ $39{\cdot}9$ $39{\cdot}0$ $39{\cdot}7$	22nd to 28th $^{s}- 39 \times 10^{-7}$

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature		Density of Air	Observed Time of Vibration	Correction on account of						Reduced Time of Vibration
					Corrected Mean	Mean change per hour			Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	
								Dehra Dun—*(Pendulum Room).*							
								26-27 November, 1906.							
	h m	s	s	′	°	°		s							s
137	2 13	34·508	− 9·55	20	18·67	+0·01	0·866	0·5073511	+ 561	−11	− 915	Not applied	− 514	−47	0·5072585
139	3 13	34·959	9·55	20	18·72	0·01	0·866	0·5072549	561	11	917		525	47	0·5071610
138	4 14	33·427	9·55	21	18·72	0·01	0·866	0·5075925	561	12	917		495	47	0·5075015
140	5 13	35·311	9·55	20	18·71	0·01	0·866	0·5071816	561	11	917		525	47	0·5070877
													Mean	...	0·5072522
137	14 19	34·510	− 9·55	21	18·07	+0·10	0·870	0·5073508	+ 561	−12	− 885		− 517	−47	0·5072608
139	15 15	34·974	9·55	21	18·14	0·10	0·870	0·5072516	561	12	889		527	47	0·5071602
138	16 15	33·436	9·55	22	18·25	0·10	0·868	0·5075905	561	13	894		496	47	0·5075016
140	17 14	35·323	9·55	20	18·34	0·10	0·867	0·5071792	561	11	899		525	47	0·5070871
													Mean	...	0·5072524
													Time of Vibration of Mean Pendulum	...	**0·5072523**
								27-28 November, 1906.							
140	2 13	35·328	− 9·60	23	18·53	+0·04	0·867	0·5071781	+564	−14	− 908	Not applied	− 525	−47	0·5070851
138	3 15	33·443	9·60	21	18·60	0·04	0·866	0·5075888	564	12	911		495	47	0·5074987
139	4 14	34·971	9·60	21	18·63	0·04	0·866	0·5072525	564	12	913		525	47	0·5071592
137	5 14	34·507	9·60	19	18·64	0·04	0·866	0·5073515	564	10	913		514	47	0·5072595
													Mean	...	0·5072506
140	14 17	35·330	− 9·60	23	18·08	+0·08	0·869	0·5071778	+564	−14	− 886		− 527	−47	0·5070868
138	15 18	33·444	9·60	22	18·13	0·08	0·867	0·5075886	564	13	888		496	47	0·5075006
139	16 19	34·972	9·60	24	18·21	0·08	0·866	0·5072523	564	15	892		525	47	0·5071608
137	17 20	34·510	9·60	20	18·32	0·08	0·864	0·5073508	564	11	898		513	47	0·5072603
													Mean	...	0·5072521
													Time of Vibration of Mean Pendulum	...	**0·5072514**
								28-29 November, 1906.							
139	2 21	34·965	− 9·49	27	18·52	0·00	0·863	0·5072537	+557	−20	− 907	Not applied	− 523	−47	0·5071597
137	3 24	34·504	9·49	19	18·52	0·00	0·863	0·5073520	557	10	907		513	47	0·5072600
140	4 27	35·318	9·49	20	18·52	0·00	0·866	0·5071803	557	11	907		525	47	0·5070870
138	5 23	33·434	9·49	23	18·52	0·00	0·864	0·5075910	557	14	907		494	47	0·5075005
													Mean	...	0·5072518
139	14 23	34·982	− 9·49	23	18·05	+0·09	0·867	0·5072501	+557	−14	− 884		− 525	−47	0·5071588
137	15 25	34·510	9·49	26	18·12	0·09	0·866	0·5073507	557	18	888		514	47	0·5072597
140	16 30	35·329	9·49	20	18·21	0·09	0·866	0·5071778	557	11	892		525	47	0·5070860
138	17 30	33·439	9·49	23	18·32	0·09	0·864	0·5075897	557	14	898		494	47	0·5075001
													Mean	...	0·5072512
													Time of Vibration of Mean Pendulum	...	**0·5072515**
								Hardwar.							
								7-8 December, 1906.							
	h m	s	s	′	°	°		s							s
140	21 31	34·663	+16·19	19	18·12	−0·08	0·904	0·5073178	− 950	−10	− 888	Not applied	− 548	−64	0·5070718
138	22 29	32·846	16·19	19	18·13	0·08	0·906	0·5077290	950	10	888		518	64	0·5074860
139	23 28	34·328	16·19	18	18·04	0·08	0·906	0·5073903	950	9	884		549	64	0·5071447
137	0 29	33·905	16·19	17	17·91	0·08	0·906	0·5074841	950	8	878		538	64	0·5072403
													Mean	...	0·5072357
140	10 3	34·733	+16·19	18	15·42	+0·37	0·915	0·5073028	− 950	− 9	− 756		− 554	−64	0·5070695
138	10 54	32·898	16·19	20	15·78	0·37	0·913	0·5077165	950	11	773		522	64	0·5074845
139	11 51	34·369	16·19	20	16·14	0·37	0·912	0·5073812	950	11	791		553	64	0·5071443
137	12 49	33·932	16·19	18	16·46	0·37	0·910	0·5074780	950	9	807		541	64	0·5072409
													Mean	...	0·5072348
													Time of Vibration of Mean Pendulum	...	**0·5072353**

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
8-9 December, 1906.															
	h m	s	s	′	°	°		s							s
137	21 20	33·902	+16·40	19	17·69	+0·01	0·907	0·5074846	−963	−10	−867	Not applied	−539	−64	0·5072403
139	22 20	34·327	16·40	18	17·75	0·01	0·907	0·5073906	963	9	870		550	64	0·5071450
138	23 22	32·849	16·40	19	17·74	0·01	0·909	0·5077282	963	10	869		520	64	0·5074856
140	0 22	34·671	16·40	18	17·73	0·01	0·907	0·5073162	963	9	869		550	64	0·5070707
													Mean	...	0·5072354
137	9 39	33·912	+16·40	13	17·30	+0·16	0·910	0·5074825	−963	−5	−848		−541	−64	0·5072404
139	10 41	34·335	16·40	19	17·51	0·16	0·909	0·5073887	963	10	858		551	64	0·5071441
138	11 44	32·852	16·40	19	17·66	0·16	0·907	0·5077275	963	10	865		519	64	0·5074854
140	12 37	34·667	16·40	19	17·78	0·16	0·906	0·5073172	963	10	871		549	64	0·5070715
													Mean	...	0·5072354
								Time of Vibration of Mean Pendulum						...	**0·5072354**
9-10 December, 1906.															
140	21 31	34·649	+16·49	20	18·46	−0·06	0·908	0·5073207	−968	−11	−905	Not applied	−550	−64	0·5070709
138	22 32	32·832	16·49	20	18·50	0·06	0·906	0·5077322	968	11	907		518	64	0·5074854
139	23 36	34·313	16·49	18	18·42	0·06	0·907	0·5073937	968	9	903		550	64	0·5071443
137	0 38	33·887	16·49	18	18·27	0·06	0·907	0·5074880	968	9	895		539	64	0·5072405
													Mean	...	0·5072353
140	9 31	34·683	+16·49	20	17·04	+0·27	0·911	0·5073135	−968	−11	−835		−552	−64	0·5070705
138	10 36	32·855	16·49	20	17·42	0·27	0·909	0·5077268	968	11	854		520	64	0·5074851
139	11 44	34·331	16·49	18	17·71	0·27	0·909	0·5073897	968	9	868		551	64	0·5071437
137	12 46	33·894	16·49	17	17·95	0·27	0·907	0·5074863	968	8	880		539	64	0·5072404
													Mean	...	0·5072349
								Time of Vibration of Mean Pendulum						...	**0·5072351**
Roorkee.															
16-17 December, 1906.															
	h m	s	s	′	°	°		s							s
137	3 27	34·249	+ 4·90	17	16·57	+0·14	0·908	0·5074076	−288	−8	−812	Not applied	−539	−43	0·5072386
139	4 28	34·683	4·90	19	16·76	0·14	0·908	0·5073135	288	10	821		550	43	0·5071423
138	5 29	33·173	4·90	20	16·92	0·14	0·907	0·5076515	288	11	829		519	43	0·5074825
140	6 30	35·022	4·90	18	16·99	0·14	0·907	0·5072418	288	9	833		550	43	0·5070695
													Mean	...	0·5072332
137	15 36	34·235	+ 4·90	19	16·75	+0·08	0·912	0·5074108	−288	−10	−821		−542	−43	0·5072404
139	16 38	34·674	4·90	20	16·86	0·08	0·912	0·5073156	288	11	826		553	43	0·5071435
138	17 44	33·167	4·90	19	16·93	0·08	0·911	0·5076529	288	10	830		521	43	0·5074837
140	18 39	35·016	4·90	18	17·00	0·08	0·908	0·5072430	288	9	833		550	43	0·5070707
													Mean	...	0·5072346
								Time of Vibration of Mean Pendulum						...	**0·5072339**
17-18 December, 1906.															
140	3 24	35·012	+ 5·08	20	17·11	+0·01	0·911	0·5072437	−298	−11	−838	Not applied	−552	−43	0·5070695
138	4 26	33·158	5·08	19	17·13	0·01	0·910	0·5076549	298	10	839		521	43	0·5074838
139	5 25	34·666	5·08	19	17·13	0·01	0·910	0·5073172	298	10	839		551	43	0·5071431
137	6 26	34·226	5·08	18	17·13	0·01	0·910	0·5074129	298	9	839		541	43	0·5072399
													Mean	...	0·5072341
140	15 48	35·037	+ 5·08	20	16·34	+0·10	0·913	0·5072386	−298	−11	−801		−553	−43	0·5070680
138	16 42	33·179	5·08	19	16·40	0·10	0·913	0·5076502	298	10	804		522	43	0·5074825
139	17 33	34·686	5·08	20	16·51	0·10	0·912	0·5073130	298	11	809		553	43	0·5071416
137	18 31	34·246	5·08	17	16·59	0·10	0·911	0·5074085	298	8	813		541	43	0·5072382
													Mean	...	0·5072326
								Time of Vibration of Mean Pendulum						...	**0·5072334**

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature		Density of Air	Observed Time of Vibration	Correction on account of						Reduced Time of Vibration
					Corrected Mean	Mean change per hour			Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	
								19-20 December, 1906.							
	h m	s	s	′	°	°		s							s
137	3 43	34·243	+ 4·66	19	16·89	+0·01	0·912	0·5074091	− 274	−10	− 828	Not applied	− 542	−43	0·5072394
139	4 43	34·686	4·66	19	16·91	0·01	0·912	0·5073130	274	10	829		553	43	0·5071421
138	5 44	33·176	4·66	19	16·91	0·01	0·912	0·5076509	274	10	829		522	43	0·5074831
140	6 44	35·027	4·66	18	16·90	0·01	0·912	0·5072408	274	9	828		553	43	0·5070701
													Mean	...	0·5072337
137	15 58	34·258	+ 4·66	19	16·35	+0·07	0·914	0·5074055	− 274	−10	− 801		− 543	−43	0·5072384
139	16 52	34·693	4·66	19	16·46	0·07	0·913	0·5073115	274	10	807		553	43	0·5071428
138	17 45	33·187	4·66	20	16·52	0·07	0·913	0·5076483	274	11	809		522	43	0·5074824
140	18 50	35·036	4·66	18	16·57	0·07	0·911	0·5072390	274	9	812		552	43	0·5070700
													Mean	...	0·5072334
									Time of Vibration of Mean Pendulum					...	**0·5072336**
								20-21 December, 1906.							
140	3 57	35·029	+ 4·84	20	16·75	+0·03	0·911	0·5072402	− 284	−11	− 821	Not applied	− 552	−43	0·5070691
138	4 48	33·175	4·84	20	16·77	0·03	0·911	0·5076509	284	11	822		521	43	0·5074828
139	5 43	34·684	4·84	18	16·80	0·03	0·911	0·5073133	284	9	823		552	43	0·5071422
137	6 40	34·244	4·84	18	16·81	0·03	0·911	0·5074087	284	9	824		541	43	0·5072386
													Mean	...	0·5072332
140	15 51	35·039	+ 4·84	19	16·43	+0·03	0·914	0·5072382	− 284	−10	− 805		− 554	−43	0·5070686
138	16 54	33·173	4·84	19	16·49	0·03	0·914	0·5076515	284	10	808		523	43	0·5074847
139	17 53	34·693	4·84	19	16·53	0·03	0·914	0·5073113	284	10	810		554	43	0·5071412
137	18 59	34·252	4·84	17	16·53	0·03	0·914	0·5074070	284	8	810		543	43	0·5072382
													Mean	...	0·5072332
									Time of Vibration of Mean Pendulum					...	**0·5072332**
								Nojli.							
								26-27 December, 1906.							
	h m	s	s	′	°	°		s							s
137	4 16	34·419	+ 0·10	19	14·92	−0·08	0·920	0·5073705	− 6	−10	− 731	Not applied	− 546	−59	0·5072353
139	5 16	34·857	0·10	19	14·92	0·08	0·921	0·5072765	6	10	731		558	59	0·5071401
138	6 18	33·342	0·10	17	14·82	0·08	0·923	0·5076122	6	8	726		528	59	0·5074795
140	7 18	35·219	0·10	19	14·70	0·08	0·923	0·5072009	6	10	720		559	59	0·5070655
													Mean	...	0·5072301
137	16 34	34·427	+ 0·10	19	14·53	+0·40	0·923	0·5073688	− 6	−10	− 712		− 548	−59	0·5072353
139	17 27	34·856	0·10	19	14·91	0·40	0·922	0·5072767	6	10	731		559	59	0·5071402
138	18 23	33·327	0·10	21	15·26	0·40	0·919	0·5076158	6	12	748		526	59	0·5074807
140	19 18	35·189	0·10	19	15·61	0·40	0·918	0·5072068	6	10	765		556	59	0·5070672
													Mean	...	0·5072309
									Time of Vibration of Mean Pendulum					...	**0·5072305**
								27-28 December, 1906.							
140	4 16	35·195	+ 0·27	21	15·54	−0·03	0·919	0·5072058	− 16	−12	− 761	Not applied	− 557	−59	0·5070653
138	5 17	33·320	0·27	20	15·55	0·03	0·919	0·5076172	16	11	762		526	59	0·5074798
139	6 18	34·845	0·27	19	15·54	0·03	0·919	0·5072792	16	10	761		557	59	0·5071389
137	7 17	34·403	0·27	18	15·45	0·03	0·919	0·5073740	16	9	757		546	59	0·5072353
													Mean	...	0·5072298
140	16 34	35·198	+ 0·27	20	15·59	+0·31	0·918	0·5072050	− 16	−11	− 764		− 556	−59	0·5070644
138	17 30	33·315	0·27	21	15·95	0·31	0·916	0·5076186	16	12	782		524	59	0·5074793
139	18 22	34·830	0·27	16	16·23	0·31	0·916	0·5072823	16	7	795		555	59	0·5071391
137	19 25	34·385	0·27	19	16·46	0·31	0·913	0·5073780	16	10	807		542	59	0·5072346
													Mean	...	0·5072294
									Time of Vibration of Mean Pendulum					...	**0·5072296**

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
28-29 December, 1906.															
	h m	s	s	′	°	°		s							s
137	4 22	34·390	+ 0·25	21	16·29	−0·06	0·916	0·5073768	− 15	−12	− 798	Not applied	− 544	−59	0·5072340
139	5 24	34·835	0·25	19	16·28	0·06	0·916	0·5072812	15	10	798		555	59	0·5071375
138	6 28	33·310	0·25	20	16·21	0·06	0·916	0·5076195	15	11	794		524	59	0·5074792
140	7 31	35·179	0·25	18	16·13	0·06	0·916	0·5072090	15	9	790		555	59	0·5070662
													Mean	...	0·5072292
137	16 34	34·426	+ 0·25	19	14·51	+0·32	0·921	0·5073688	− 15	−10	− 711		− 547	−59	0·5072346
139	17 26	34·860	0·25	20	14·82	0·32	0·919	0·5072760	15	11	726		557	59	0·5071392
138	18 31	33·327	0·25	20	15·16	0·32	0·917	0·5076155	15	11	743		525	59	0·5074802
140	19 32	35·191	0·25	19	15·48	0·32	0·916	0·5072065	15	10	759		555	59	0·5070667
													Mean	...	0·5072302
								Time of Vibration of Mean Pendulum						...	**0·5072297**
Kaliana.															
4-5 January, 1907.															
	h m	s	s	′	°	°		s							s
137	4 55	34·270	+ 4·72	17	16·41	−0·02	0·918	0·5074030	− 277	− 8	− 804	Not applied	− 545	−83	0·5072313
139	5 56	34·709	4·72	19	16·43	0·02	0·918	0·5073080	277	10	805		556	83	0·5071349
138	6 55	33·199	4·72	20	16·40	0·02	0·918	0·5076455	277	11	804		525	83	0·5074755
140	7 56	35·054	4·72	18	16·38	0·02	0·918	0·5072350	277	9	803		556	83	0·5070622
													Mean	...	0·5072260
137	16 50	34·272	+ 4·72	18	15·91	+0·17	0·922	0·5074025	− 277	− 9	− 780		− 548	−83	0·5072328
139	17 52	34·709	4·72	18	16·06	0·17	0·921	0·5073081	277	9	787		558	83	0·5071367
138	18 54	33·193	4·72	20	16·24	0·17	0·918	0·5076468	277	11	796		525	83	0·5074776
140	19 53	35·045	4·72	18	16·43	0·17	0·917	0·5072371	277	9	805		556	83	0·5070641
													Mean	...	0·5072278
								Time of Vibration of Mean Pendulum						...	**0·5072269**
5-6 January, 1907.															
140	4 56	35·026	+ 5·39	20	16·89	−0·17	0·917	0·5072410	− 316	−11	− 828	Not applied	− 556	−83	0·5070616
138	5 58	33·172	5·39	20	16·78	0·17	0·918	0·5076518	316	11	822		525	83	0·5074761
139	6 55	34·687	5·39	19	16·61	0·17	0·919	0·5073127	316	10	814		557	83	0·5071347
137	7 55	34·251	5·39	17	16·44	0·17	0·918	0·5074072	316	8	806		545	83	0·5072314
													Mean	...	0·5072260
140	17 6	35·027	+ 5·39	20	16·39	+0·18	0·917	0·5072407	− 316	−11	− 803		− 556	−83	0·5070638
138	18 5	33·168	5·39	20	16·57	0·18	0·916	0·5076529	316	11	812		524	83	0·5074783
139	19 5	34·670	5·39	19	16·76	0·18	0·914	0·5073163	316	10	821		554	83	0·5071379
137	20 3	34·228	5·39	18	16·92	0·18	0·913	0·5074122	316	9	829		542	83	0·5072343
													Mean	...	0·5072286
								Time of Vibration of Mean Pendulum						...	**0·5072273**
8-9 January, 1907.															
137	5 7	34·225	+ 5·89	18	17·16	+0·03	0·911	0·5074130	− 346	− 9	− 841	Not applied	− 541	−78	0·5072315
139	6 7	34·660	5·89	18	17·19	0·03	0·911	0·5073185	346	9	842		552	78	0·5071358
138	7 7	33·149	5·89	20	17·23	0·03	0·911	0·5076571	346	11	844		521	78	0·5074771
140	8 7	34·999	5·89	18	17·26	0·03	0·911	0·5072466	346	9	846		552	78	0·5070635
													Mean	...	0·5072270
137	17 16	34·219	+ 5·89	18	17·33	+0·05	0·912	0·5074145	− 346	− 9	− 849		− 542	−78	0·5072321
139	18 17	34·652	5·89	18	17·40	0·05	0·912	0·5073202	346	9	853		553	78	0·5071363
138	19 19	33·142	5·89	20	17·47	0·05	0·911	0·5076589	346	11	856		521	78	0·5074777
140	20 18	34·994	5·89	18	17·49	0·05	0·911	0·5072476	346	9	857		552	78	0·5070634
													Mean	...	0·5072274
								Time of Vibration of Mean Pendulum						...	**0·507 2272**

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
9-10 January, 1907.															
	h m	s	s	′	°	°		s							s
140	5 8	35·046	+ 5·89	20	15·34	+0·13	0·918	0·5072367	− 346	−11	− 752	Not applied	− 556	−78	0·5070624
138	6 5	33·185	5·89	20	15·47	0·13	0·917	0·5076488	346	11	758		525	78	0·5074770
139	7 8	34·692	5·89	18	15·60	0·13	0·913	0·5073116	346	9	764		553	78	0·5071366
137	8 9	34·249	5·89	18	15·74	0·13	0·917	0·5074075	346	9	771		545	78	0·5072326
													Mean	...	0·5072272
140	17 23	35·015	+ 5·89	20	16·63	+0·10	0·917	0·5072431	− 346	−11	− 815		− 556	−78	0·5070625
138	18 18	33·159	5·89	20	16·74	0·10	0·916	0·5076549	346	11	820		524	78	0·5074770
139	19 14	34·664	5·89	18	16·83	0·10	0·916	0·5073178	346	9	825		555	78	0·5071365
137	20 11	34·224	5·89	17	16·92	0·10	0·915	0·5074130	346	8	829		544	78	0·5072325
													Mean	...	0·5072271
													Time of Vibration of Mean Pendulum	...	**0·5072272**
10-11 January, 1907.															
137	5 16	34·224	+ 5·91	19	16·95	−0·01	0·916	0·5074132	− 347	−10	− 831	Not applied	− 544	−78	0·5072322
139	6 17	34·664	5·91	18	16·94	0·01	0·916	0·5073176	347	9	830		555	78	0·5071357
138	7 21	33·155	5·91	19	16·93	0·01	0·916	0·5076558	347	10	830		524	78	0·5074769
140	8 22	35·006	5·91	18	16·93	0·01	0·916	0·5072451	347	9	830		555	78	0·5070632
													Mean	...	0·5072270
137	17 12	34·238	+ 5·91	18	16·61	+0·04	0·921	0·5074100	− 347	− 9	− 814		− 547	−78	0·5072305
139	18 15	34·668	5·91	19	16·70	0·04	0·918	0·5073168	347	10	818		556	78	0·5071359
138	19 19	33·158	5·91	19	16·73	0·04	0·918	0·5076551	347	10	820		525	78	0·5074771
140	20 20	35·013	5·91	19	16·78	0·04	0·917	0·5072435	347	10	822		556	78	0·5070622
													Mean	...	0·5072264
													Time of Vibration of Mean Pendulum	...	**0·5072267**
Meerut.															
31st January—1st February, 1907.															
	h m	s	s	′	°	°		s							s
137	3 26	34·421	− 1·35	19	17·57	+0·09	0·912	0·5073700	+ 79	−10	− 861	Not applied	− 542	−46	0·5072320
139	4 25	34·858	1·35	19	17·65	0·09	0·911	0·5072763	79	10	865		552	46	0·5071369
138	5 28	33·333	1·35	20	17·73	0·09	0·911	0·5076145	79	11	869		521	46	0·5074777
140	6 24	35·197	1·35	20	17·82	0·09	0·911	0·5072052	79	11	873		552	46	0·5070649
													Mean	...	0·5072279
137	15 41	34·419	− 1·35	20	17·53	+0·08	0·913	0·5073706	+ 79	−11	− 859		− 542	−46	0·5072327
139	16 38	34·861	1·35	19	17·57	0·08	0·913	0·5072757	79	10	861		553	46	0·5071366
138	17 31	33·334	1·35	21	17·65	0·08	0·912	0·5076141	79	12	865		522	46	0·5074775
140	18 23	35·201	1·35	19	17·72	0·08	0·912	0·5072046	79	10	868		553	46	0·5070648
													Mean	...	0·5072279
													Time of Vibration of Mean Pendulum	...	**0·5072279**
18-19 February, 1907.															
137	4 30	34·416	− 0·91	20	17·52	+0·02	0·913	0·5073711	+ 53	−11	− 858	Not applied	− 542	−43	0·5072310
139	5 29	34·851	0·91	20	17·55	0·02	0·912	0·5072778	53	11	860		553	43	0·5071364
138	6 28	33·327	0·91	21	17·57	0·02	0·912	0·5076157	53	12	861		522	43	0·5074772
140	7 27	35·195	0·91	19	17·59	0·02	0·912	0·5072058	53	10	862		553	43	0·5070643
													Mean	...	0·5072272
137	16 45	34·397	− 0·91	20	17·78	+0·09	0·911	0·5073752	+ 53	−11	− 871		− 541	−43	0·5072339
139	17 34	34·836	0·91	21	17·91	0·09	0·911	0·5072810	53	12	878		552	43	0·5071378
138	18 28	33·317	0·91	21	17·96	0·09	0·910	0·5076180	53	12	880		521	43	0·5074777
140	19 26	35·184	0·91	20	18·08	0·09	0·909	0·5072079	53	11	886		551	43	0·5070641
													Mean	...	0·5072284
													Time of Vibration of Mean Pendulum	...	**0·5072278**

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	Reduced Time of Vibration
								24-25 February, 1907.							
	h m	s	s	′	°	°		s							s
140	4 51	35·150	+ 0·19	21	18·20	+0·03	0·909	0·5072150	− 11	−12	− 892	Not applied	− 551	−43	0·5070641
138	5 49	33·280	0·19	21	18·29	0·03	0·910	0·5076266	11	12	896		521	43	0·5074783
139	6 46	34·800	0·19	21	18·29	0·03	0·910	0·5072886	11	12	896		551	43	0·5071373
137	7 46	34·356	0·19	18	18·32	0·03	0·909	0·5073843	11	9	898		540	43	0·5072342
													Mean	...	0·5072285
140	16 3	35·153	+ 0·19	21	18·33	+0·08	0·911	0·5072145	− 11	−12	− 898		− 552	−43	0·5070629
138	16 57	33·286	0·19	21	18·42	0·08	0·910	0·5076252	11	12	903		521	43	0·5074762
139	17 53	34·800	0·19	20	18·52	0·08	0·909	0·5072886	11	11	907		551	43	0·5071363
137	18 54	34·356	0·19	19	18·57	0·08	0·909	0·5073843	11	10	910		540	43	0·5072329
													Mean	...	0·5072271
											Time of Vibration of Mean Pendulum			...	**0·507 2278**
								Gesupur.							
								3-4 March, 1907.							
	h m	s	s	′	°	°		s							s
137	8 36	34·390	− 3·09	21	19·72	−0·08	0·907	0·5073768	+ 181	−12	− 966	Not applied	− 539	−42	0·5072390
139	9 36	34·833	3·09	21	19·72	0·08	0·907	0·5072817	181	12	966		550	42	0·5071428
138	10 36	33·312	3·09	22	19·62	0·08	0·908	0·5076190	181	13	961		519	42	0·5074836
140	11 34	35·186	3·09	21	19·50	0·08	0·908	0·5072075	181	12	956		550	42	0·5070696
													Mean	...	0·5072338
137	20 45	34·405	− 3·09	21	18·72	+0·08	0·912	0·5073735	+ 181	−12	− 917		− 542	−42	0·5072403
139	21 43	34·848	3·09	21	18·72	0·08	0·911	0·5072786	181	12	917		552	42	0·5071444
138	22 42	33·323	3·09	22	18·83	0·08	0·910	0·5076168	181	13	923		521	42	0·5074850
140	23 40	35·191	3·09	20	18·92	0·08	0·909	0·5072065	181	11	927		551	42	0·5070715
													Mean	...	0·5072353
											Time of Vibration of Mean Pendulum			...	**0·5072345**
								4-5 March, 1907.							
140	8 23	35·171	− 3·02	22	19·54	−0·01	0·907	0·5072107	+ 177	−13	− 957	Not applied	− 550	−42	0·5070722
138	9 22	33·305	3·02	22	19·53	0·01	0·908	0·5076209	177	13	957		519	42	0·5074855
139	10 21	34·834	3·02	21	19·52	0·01	0·908	0·5072813	177	12	956		550	42	0·5071430
137	11 20	34·385	3·02	16	19·52	0·01	0·906	0·5073780	177	7	956		538	42	0·5072414
													Mean	...	0·5072355
140	20 28	35·197	− 3·02	20	19·05	+0·08	0·910	0·5072053	+ 177	−11	− 933		− 551	−42	0·5070693
138	21 26	33·319	3·02	22	19·11	0·08	0·909	0·5076175	177	13	936		520	42	0·5074841
139	22 24	34·842	3·02	21	19·17	0·08	0·909	0·5072798	177	12	939		551	42	0·5071431
137	23 24	34·392	3·02	19	19·30	0·08	0·908	0·5073765	177	10	946		539	42	0·5072405
													Mean	...	0·5072343
											Time of Vibration of Mean Pendulum			...	**0·5072349**
								5-6 March, 1907.							
140	8 23	35·168	− 2·93	22	19·92	−0·10	0·904	0·5072112	+ 172	−13	− 976	Not applied	− 548	−42	0·5070705
138	9 23	33·301	2·93	22	19·91	0·10	0·906	0·5076216	172	13	976		518	42	0·5074839
139	10 22	34·829	2·93	20	19·78	0·10	0·906	0·5072825	172	11	969		549	42	0·5071426
137	11 22	34·384	2·93	20	19·69	0·10	0·907	0·5073781	172	11	965		539	42	0·5072396
													Mean	...	0·5072342
140	20 20	35·189	− 2·93	22	19·05	+0·14	0·908	0·5072070	+ 172	−13	− 933		− 550	−42	0·5070704
138	21 21	33·315	2·93	22	19·13	0·14	0·907	0·5076183	172	13	937		519	42	0·5074844
139	22 23	34·836	2·93	20	19·29	0·14	0·907	0·5072811	172	11	945		550	42	0·5071435
137	23 21	34·386	2·93	20	19·44	0·14	0·904	0·5073777	172	11	953		537	42	0·5072406
													Mean	...	0·5072347
											Time of Vibration of Mean Pendulum			...	**0·5072345**

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature		Density of Air	Observed Time of Vibration	Correction on account of						Reduced Time of Vibration
					Corrected Mean	Mean change per hour			Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	
							Mohan.								
							16-17 March, 1907.								
	h m	s	s	′	°	°		s							s
137	8 47	34·403	− 1·92	19	16·57	+0·05	0·885	0·5073741	+ 113	−10	− 812	Not applied	− 526	−71	0·5072435
139	9 44	34·845	1·92	20	16·62	0·05	0·885	0·5072790	113	11	814		536	71	0·5071471
138	10 44	33·316	1·92	20	16·69	0·05	0·884	0·5076182	113	11	818		506	71	0·5074889
140	11 43	35·188	1·92	19	16·72	0·05	0·884	0·5072071	113	10	819		536	71	0·5070748
													Mean	...	0·5072386
137	20 52	34·402	− 1·92	20	16·58	+0·05	0·885	0·5073741	+ 113	−11	− 812		− 526	−71	0·5072434
139	21 50	34·844	1·92	19	16·67	0·05	0·885	0·5072792	113	10	817		536	71	0·5071471
138	22 50	33·316	1·92	20	16·72	0·05	0·885	0·5076182	113	11	819		506	71	0·5074888
140	23 49	35·183	1·92	19	16·73	0·05	0·884	0·5072080	113	10	820		536	71	0·5070756
													Mean	...	0·5072387
											Time of Vibration of Mean Pendulum			...	**0·5072387**
							17-18 March, 1907.								
140	8 47	35·183	− 1·84	20	16·76	−0·07	0·886	0·5072081	+ 108	−11	− 821	Not applied	− 537	−71	0·5070749
138	9 46	33·313	1·84	20	16·73	0·07	0·887	0·5076188	108	11	820		507	71	0·5074887
139	10 47	34·840	1·84	20	16·67	0·07	0·887	0·5072802	108	11	817		538	71	0·5071473
137	11 47	34·396	1·84	18	16·56	0·07	0·887	0·5073756	108	9	811		527	71	0·5072446
													Mean	...	0·5072389
140	20 49	35·205	− 1·84	21	15·88	+0·15	0·889	0·5072036	+ 108	−12	− 778		− 539	−71	0·5070744
138	21 50	33·328	1·84	21	16·06	0·15	0·889	0·5076155	108	12	786		509	71	0·5074885
139	22 49	34·848	1·84	20	16·18	0·15	0·888	0·5072786	108	11	793		538	71	0·5071481
137	23 50	34·393	1·84	18	16·33	0·15	0·888	0·5073761	108	9	800		527	71	0·5072462
													Mean	...	0·5072393
											Time of Vibration of Mean Pendulum			...	**0·5072391**
							Asarori.								
							24-25 March, 1907.								
	h m	s	s	′	°	°		s							s
137	9 50	34·265	+ 1·99	21	16·00	+0·05	0·861	0·5074042	− 117	−12	− 784	Not applied	− 511	−50	0·5072568
139	10 49	34·704	1·99	19	16·07	0·05	0·861	0·5073090	117	10	787		522	50	0·5071604
138	11 48	33·193	1·99	22	16·12	0·05	0·860	0·5076468	117	13	790		492	50	0·5075006
140	12 47	35·044	1·99	22	16·14	0·05	0·860	0·5072371	117	13	791		521	50	0·5070879
													Mean	...	0·5072514
137	21 57	34·245	+ 1·99	21	16·73	0·00	0·860	0·5074085	− 117	−12	− 820		− 511	−50	0·5072575
139	22 56	34·686	1·99	21	16·73	0·00	0·859	0·5073129	117	12	820		521	50	0·5071609
138	23 54	33·177	1·99	22	16·73	0·00	0·860	0·5076507	117	13	820		492	50	0·5075015
140	0 50	35·029	1·99	21	16·73	0·00	0·859	0·5072403	117	12	820		521	50	0·5070883
													Mean	...	0·5072521
											Time of Vibration of Mean Pendulum			...	**0·5072517**
							25-26 March, 1907.								
140	9 58	35·032	+ 2·05	23	16·61	+0·04	0·860	0·5072396	− 120	−14	− 814	Not applied	− 521	−50	0·5070877
138	10 57	33·177	2·05	22	16·65	0·04	0·860	0·5076507	120	13	816		492	50	0·5075016
139	11 54	34·689	2·05	21	16·68	0·04	0·859	0·5073123	120	12	817		521	50	0·5071603
137	12 57	34·247	2·05	19	16·71	0·04	0·857	0·5074082	120	10	819		509	50	0·5072574
													Mean	...	0·5072518
140	20 9	35·038	+ 2·05	22	16·50	+0·10	0·860	0·5072385	− 120	−13	− 809		− 521	−50	0·5070872
138	21 8	33·181	2·05	22	16·55	0·10	0·859	0·5076498	120	13	811		419	50	0·5075013
139	22 3	34·690	2·05	22	16·68	0·10	0·859	0·5073118	120	13	817		521	50	0·5071597
137	22 58	34·246	2·05	20	16·74	0·10	0·859	0·5074085	120	11	820		510	50	0·5072574
													Mean	...	0·5072514
											Time of Vibration of Mean Pendulum			...	**0·5072516**

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature		Density of Air	Observed Time of Vibration	Correction on account of						Reduced Time of Vibration
					Corrected Mean	Mean change per hour			Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	
							26-27 March, 1907.								
	h m	s	s	′	°	°		s							s
137	9 55	34·244	+ 2·05	22	16·77	0·00	0·859	0·5074088	− 120	−13	− 822	Not applied	− 510	−50	0·5072573
139	10 52	34·685	2·05	21	16·77	0·00	0·859	0·5073131	120	12	822		521	50	0·5071606
138	21 55	33·176	+ 2·05	20	16·72	+0·04	0·861	0·5076509	− 120	−11	− 819		− 492	−50	0·5075017
140	22 56	35·025	2·05	21	16·80	0·04	0·861	0·5072411	120	12	823		522	50	0·5070884
													Time of Vibration of Mean Pendulum	...	**0·5072520**
													Mean 25-27	...	**0·5072518**
													General Mean	...	**0·5072518**
							Fatehpur.								
							4-5 April, 1907.								
	h m	s	s	′	°	°		s							s
137	10 16	34·149	+ 4·19	21	22·72	−0·09	0·869	0·5074297	− 246	−12	−1113	Not applied	− 516	−66	0·5072344
139	11 17	34·594	4·19	21	22·60	0·09	0·870	0·5073327	246	12	1107		527	66	0·5071369
138	12 18	33·091	4·19	17	22·52	0·09	0·871	0·5076707	246	8	1103		498	66	0·5074786
140	13 18	34·934	4·19	20	22·42	0·09	0·870	0·5072603	246	11	1099		527	66	0·5070654
													Mean	...	0·5072288
137	22 16	34·160	+ 4·19	21	22·31	+0·11	0·870	0·5074271	− 246	−12	−1093		− 517	−66	0·5072337
139	23 18	34·599	4·19	21	22·38	0·11	0·868	0·5073315	246	12	1097		526	66	0·5071368
138	0 18	33·092	4·19	22	22·51	0·11	0·868	0·5076707	246	13	1103		496	66	0·5074783
140	1 17	34·931	4·19	21	22·60	0·11	0·867	0·5072609	246	12	1107		525	66	0·5070653
													Mean	...	0·5072285
													Time of Vibration of Mean Pendulum	...	**0·5072287**
							5-6 April, 1907.								
140	10 17	34·905	+ 4·58	23	23·32	−0·08	0·863	0·5072663	− 269	−14	−1143	Not applied	− 523	−66	0·5070648
138	11 18	33·069	4·58	20	23·22	0·08	0·864	0·5076761	269	11	1138		494	66	0·5074783
139	12 17	34·572	4·58	21	23·13	0·08	0·864	0·5073376	269	12	1133		524	66	0·5071372
137	13 18	34·132	4·58	19	23·09	0·08	0·865	0·5074335	269	10	1131		514	66	0·5072345
													Mean	...	0·5072287
140	22 22	34·911	+ 4·58	22	22·90	+0·13	0·865	0·5072652	− 269	−13	−1122		− 524	−66	0·5070658
138	23 23	33·066	4·58	22	22·99	0·13	0·864	0·5076765	269	13	1127		494	66	0·5074796
139	0 23	34·566	4·58	21	23·13	0·13	0·864	0·5073387	269	12	1133		524	66	0·5071383
137	1 25	34·121	4·58	20	23·29	0·13	0·862	0·5074359	269	11	1141		512	66	0·5072360
													Mean	...	0·5072299
													Time of Vibration of Mean Pendulum	...	**0·5072293**
							Kalsi.								
							9-10 April, 1907.								
	h m	s	s	′	°	°		s							s
137	10 40	34·210	+ 0·07	22	24·09	−0·01	0·860	0·5074162	− 4	−13	−1180	Not applied	− 511	−69	0·5072385
139	11 38	34·656	0·07	21	24·09	0·01	0·860	0·5073195	4	12	1180		521	69	0·5071409
138	12 41	33·149	0·07	21	24·09	0·01	0·860	0·5076571	4	12	1180		492	69	0·5074814
140	13 38	34·996	0·07	21	24·06	0·01	0·860	0·5072472	4	12	1179		521	69	0·5070687
													Mean	...	0·5072324
137	22 47	34·225	+ 0·07	21	23·51	+0·11	0·861	0·5074130	− 4	−12	−1152		− 511	−69	0·5072382
139	23 46	34·662	0·07	22	23·62	0·11	0·861	0·5073180	4	13	1157		522	69	0·5071415
138	0 46	33·152	0·07	22	23·73	0·11	0·859	0·5076566	4	13	1163		491	69	0·5074826
140	1 46	34·997	0·07	20	23·87	0·11	0·859	0·5072470	4	11	1170		521	69	0·5070695
													Mean	...	0·5072329
													Time of Vibration of Mean Pendulum	...	**0·5072327**

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature: Corrected Mean	Temperature: Mean change per hour	Density of Air	Observed Time of Vibration	Correction on account of: Clock Rate	Correction on account of: Arc	Correction on account of: Temperature	Correction on account of: Lag	Correction on account of: Density of Air	Correction on account of: Flexure	Reduced Time of Vibration
								10-11 April, 1907.							
	h m	s	s	′	°	°		s							s
140	10 53	34·999	+ 0·03	23	23·70	−0·05	0·860	0·5072465	− 2	−14	−1161	Not applied	− 521	−69	0·5070698
138	11 51	33·149	0·03	22	23·70	0·05	0·860	0·5076571	2	13	1161		492	69	0·5074834
139	12 48	34·664	0·03	22	23·64	0·05	0·860	0·5073178	2	13	1158		521	69	0·5071415
137	13 49	34·221	0·03	20	23·55	0·05	0·859	0·5074138	2	11	1154		510	69	0·5072392
													Mean	...	0·5072335
140	22 58	35·025	+ 0·03	20	22·92	+0·14	0·865	0·5072411	− 2	−11	−1123		− 524	−69	0·5070682
138	23 60	33·167	0·03	23	23·06	0·14	0·863	0·5076530	2	14	1130		494	69	0·5074821
139	0 54	34·671	0·03	21	23·18	0·14	0·863	0·5073160	2	12	1136		523	69	0·5071418
137	1 55	34·222	0·03	19	23·33	0·14	0·861	0·5074136	2	10	1143		511	69	0·5072401
													Mean	...	0·5072330
									Time of Vibration of Mean Pendulum					...	**0·5072333**
								Rajpur.							
								18-19 April, 1907.							
	h m	s	s	′	°	°		s							s
137	11 32	34·332	− 5·18	23	18·92	+0·08	0·825	0·5073896	+ 304	−14	− 927	Not applied	− 490	−55	0·5072714
139	12 30	34·776	5·18	23	18·96	0·08	0·825	0·5072937	304	14	929		500	55	0·5071743
138	13 30	33·254	5·18	24	19·07	0·08	0·823	0·5076327	304	15	934		471	55	0·5075156
140	14 29	35·114	5·18	22	19·12	0·08	0·823	0·5072226	304	13	937		499	55	0·5071026
													Mean	...	0·5072660
137	23 30	34·325	− 5·18	23	19·10	+0·18	0·824	0·5073910	+ 304	−14	− 936		− 489	−55	0·5072720
139	0 29	34·765	5·18	23	19·28	0·18	0·823	0·5072960	304	14	945		499	55	0·5071751
138	1 30	33·243	5·18	23	19·45	0·18	0·823	0·5076352	304	14	953		471	55	0·5075163
140	2 30	35·099	5·18	22	19·63	0·18	0·822	0·5072257	304	13	962		498	55	0·5071033
													Mean	...	0·5072667
									Time of Vibration of Mean Pendulum					...	**0·5072663**
								19-20 April, 1907.							
140	11 24	35·085	− 5·21	24	20·03	−0·07	0·822	0·5072286	+ 306	−15	− 981	Not applied	− 498	−55	0·5071043
138	12 24	33·230	5·21	23	19·94	0·07	0·823	0·5076382	306	14	977		471	55	0·5075171
139	13 21	34·749	5·21	21	19·88	0·07	0·822	0·5072995	306	12	974		498	55	0·5071762
137	14 21	34·303	5·21	20	19·83	0·07	0·822	0·5073958	306	11	972		488	55	0·5072738
													Mean	...	0·5072679
140	23 39	35·109	− 5·21	23	19·68	+0·19	0·822	0·5072233	+ 306	−14	− 964		− 498	−55	0·5071008
138	0 31	33·246	5·21	22	19·80	0·19	0·822	0·5076346	306	13	970		470	55	0·5075144
139	1 26	34·759	5·21	22	19·99	0·19	0·820	0·5072973	306	13	980		497	55	0·5071734
137	2 22	34·306	5·21	20	20·20	0·19	0·820	0·5073951	306	11	990		487	55	0·5072714
													Mean	...	0·5072650
									Time of Vibration of Mean Pendulum					...	**0·5072664**
								Dehra Dun.							
								29-30 March 1907.							
	h m	s	s	′	°	°		s							s
137	10 19	34·496	− 8·27	21	18·69	−0·01	0·863	0·5073538	+ 485	−12	− 916	Not applied	− 513	−49	0·5072533
139	11 20	34·944	8·27	17	18·70	0·01	0·863	0·5072583	485	8	916		523	49	0·5071572
138	12 20	33·410	8·27	20	18·69	0·01	0·863	0·5075965	485	11	916		494	49	0·5074980
140	13 18	35·288	8·27	21	18·67	0·01	0·863	0·5071862	485	12	915		523	49	0·5070848
													Mean	...	0·5072483
137	22 31	34·483	− 8·27	21	18·39	+0·05	0·865	0·5073567	+ 485	−12	− 901		− 514	−49	0·5072576
139	23 30	34·929	8·27	21	18·47	0·05	0·863	0·5072613	485	12	905		523	49	0·5071609
138	0 24	33·395	8·27	22	18·52	0·05	0·863	0·5075998	485	13	907		494	49	0·5075020
140	1 22	35·276	8·27	20	18·52	0·05	0·863	0·5071888	485	11	907		523	49	0·5070883
													Mean	...	0·5072522
									Time of Vibration of Mean Pendulum					...	**0·5072503**

Pendulum	Sidereal Time	Coincidence Interval	Clock Rate	Mean Semi-Arc	Temperature		Density of Air	Observed Time of Vibration	Correction on account of						Reduced Time of Vibration
					Corrected Mean	Mean change per hour			Clock Rate	Arc	Temperature	Lag	Density of Air	Flexure	
	23-24 April 1907.														
	h m	s	s	'	°	°		s							s
137	11 50	34·215	− 2·07	19	24·00	−0·05	0·837	0·5074151	+ 122	−10	−1176	Not applied	− 497	−39	0·5072551
139	12 49	34·662	2·07	20	24·01	0·05	0·837	0·5073181	122	11	1176		507	39	0·5071570
138	13 49	33·154	2·07	21	23·93	0·05	0·838	0·5076560	122	12	1173		479	39	0·5074979
140	14 47	35·011	2·07	20	23·88	0·05	0·838	0·5072440	122	11	1170		508	39	0·5070834
													Mean	...	0·5072484
137	23 57	34·213	− 2·07	20	23·93	+0·12	0·838	0·5074157	+ 122	−11	−1173		− 498	−39	0·5072558
139	0 56	34·653	2·07	20	24·08	0·12	0·837	0·5073202	122	11	1180		507	39	0·5071587
138	1 56	33·143	2·07	21	24·17	0·12	0·836	0·5076587	122	12	1184		478	39	0·5074996
140	2 54	34·988	2·07	20	24·31	0·12	0·836	0·5072490	122	11	1191		507	39	0·5070864
													Mean	...	0·5072501
									Time of Vibration of Mean Pendulum					...	**0·5072493**
	24-25 April 1907.														
140	11 55	34·972	− 2·07	21	24·67	−0·13	0·836	0·5072523	+ 122	−12	−1209	Not applied	− 507	−39	0.5070878
138	12 55	33·132	2·07	21	24·57	0·13	0·837	0·5076612	122	12	1204		479	39	0·5075000
139	13 51	34·641	2·07	20	24·43	0·13	0·839	0·5073226	122	11	1197		508	39	0·5071593
137	14 49	34·200	2·07	19	24·33	0·13	0·838	0·5074185	122	10	1192		498	39	0·5072568
													Mean	...	0·5072510
140	23 58	34·974	− 2·07	22	24·49	+0·12	0·837	0·5072520	+ 122	−13	−1200		− 507	−39	0·5070883
138	0 58	33·127	2·07	21	24·55	0·12	0·837	0·5076625	122	12	1203		479	39	0·5075014
139	2 1	34·628	2·07	20	24·71	0·12	0·836	0·5073252	122	11	1211		507	39	0·5071606
137	3 2	34·185	2·07	19	24·81	0·12	0·835	0·5074217	122	10	1216		496	39	0·5072578
													Mean	...	0·5072520
									Time of Vibration of Mean Pendulum					...	**0·5072515**
	27-28 April, 1907.														
137	12 2	34·156	− 1·03	21	25·31	−0·02	0·834	0·5074281	+ 60	−12	−1240	Not applied	− 495	−39	0·5072555
139	13 0	34·594	1·03	20	25·29	0·02	0·836	0·5073328	60	11	1239		507	39	0·5071592
138	14 0	33·089	1·03	21	25·27	0·02	0·836	0·5076712	60	12	1238		478	39	0·5075005
140	14 56	34·932	1·03	20	25·24	0·02	0·836	0·5072608	60	11	1237		507	39	0·5070874
													Mean	...	0·5072507
137	0 5	34·154	− 1·03	21	25·14	+0·15	0·835	0·5074286	+ 60	−12	−1232		− 496	−39	0·5072567
139	1 14	34·594	1·03	22	25·33	0·15	0·835	0·5073328	60	13	1241		506	39	0·5071588
138	2 14	33·083	1·03	19	25·52	0·15	0·834	0·5076727	60	10	1250		477	39	0·5075011
140	3 11	34·930	1·03	17	25·59	0·15	0·833	0·5072611	60	8	1254		505	39	0·5070865
													Mean	...	0·5072508
									Time of Vibration of Mean Pendulum					...	**0·5072507**

THE TIME OF VIBRATION AT DEHRA DUN.

The observations at Dehra Dún in November give values of the times of vibration which agree well with those of the previous April, namely :—

Pendulum	137	138	139	140	Mean
April, 1906	0·5072598	0·5075001	0·5071599	0·5070860	0·5072515
Nov., 1906	0·5072598	0·5075005	0·5071599	0·5070866	0·5072517

But the observations at Hardwár shewed that a change had taken place in Pendulum No. 137 relatively to the others since the conclusion of the work at Dehra. I have no suggestion to offer as to the cause of this change; the journey is a very short one, the pendulums were packed and handled with the usual care and no accident of any kind is believed to have occurred.

To decide upon the best value of the time of vibration at Dehra Dún it is again necessary to have recourse to the differences between the individual pendulums and the mean pendulum. They are exhibited in Table III, the mean values at each station being given. At the beginning of the table the mean values for the former season, as shewn in Table IV, Chapter IV, are entered for comparison.

Table III.—Differences between Individual Pendulums and Mean Pendulum.

Station	Date	137	v	138	v	139	v	140	v
Mean of all stations	1905-06	− 79	...	− 2488	...	+ 912	...	+ 1655	...
Dehra Dún ...	1906 Nov. 26-29	81	...	2488	...	918	...	1651	...
Hardwár ...	1906 Dec. 7-10	− 52	+ 3	− 2500	− 3	+ 909	− 3	1645	+ 6
Roorkee ...	„ 16-21	55	0	2497	0	912	0	1640	1
Nojli ...	„ 26-29	50	+ 5	2499	− 2	907	− 5	1641	2
Kaliána ...	1907 Jan. 4-11	51	4	2500	3	909	3	1641	2
Meerut ...	„ 31-Feb. 25	50	5	2496	+ 1	909	3	1636	− 3
Gesupur ...	March 3- 6	56	− 1	2498	− 1	914	+ 2	1640	+ 1
Mohan ...	„ 16-18	56	1	2498	1	915	3	1640	1
Asarori ...	„ 24-27	56	1	2496	+ 1	912	0	1638	− 1
Fatehpur ...	April 4- 6	57	+ 2	2496	1	917	+ 5	1637	2
Kálsi ...	„ 9-11	61	6	2493	4	915	3	1639	0
Rájpur ...	„ 18-20	58	3	2494	3	916	4	1637	− 2
Dehra Dún ...	March 29-30 } April 23-28 } ...	55	0	2497	0	915	3	1638	1
Mean		55	...	2497	...	912	...	1639	...

It will be seen that after the change in Pendulum No. 137 took place, its length remained tolerably constant. There is some evidence of a tendency to return towards its former state, but the amount of the movement is not large enough to be taken into account.

Accepting the mean of the two values at the top of the table to represent the former relations of the pendulums, and the means of all the values from December to April to represent their new relations, and assuming that Pendulum No. 137 alone changed its length and that it did so by an amount causing a decrement of x in its time of vibration, we have

$$\frac{3x}{4} = (80 - 55); \frac{x}{4} = (2497 - 2488) \text{ or } (915 - 912) \text{ or } (1653 - 1639)$$

Whence $x = 33$ or 36 or 12 or 56

and the mean $x = 34$

It will therefore be necessary to reduce the time of vibration of Pendulum No. 137 at Dehra Dún in November by $34^s \times 10^{-7}$, in order to produce the period which the pendulum would have had if its length had then been the same as it was during the remainder of the season.

Thus the times of vibration at Dehra Dún before and after the season's work become :—

Table IV.—Times of Vibration at Dehra Dún.

Date	137	138	139	140	Mean
	s	s	s	s	s
November, 1906	0·5072564	0·5075005	0·5071599	0·5070866	0·5072508
March-April, 1907	0·5072560	0·5075002	0·5071590	0·5070867	0·5072505
Means	0·5072562	0·5075004	0·5071595	0·5070867	0·5072507

The value of g at each station has been computed from the differences from the above mean times of vibration at Dehra Dún, employing, as before, the value 979·063 for g at Dehra Dún, and the formula

$$g = g_0 - \frac{2g_0\,(s - s_0)}{s_0}$$

Table V.—Mean Times of Vibration and Deduced Values of g.

Station		137	188	139	140	Mean
Hardwár	s.	0·5072405	0·5074853	0·5071444	0·5070708	0·5072353
		− 157	− 151	− 151	− 159	− 154
	g.	979·124	979·121	979·121	979·124	979·122
Roorkee	s.	0·5072390	0·5074832	0·5071423	0·5070695	0·5072335
		− 172	− 172	− 172	− 172	− 172
	g.	979·129	979·129	979·129	979·129	979·129
Nojli	s.	0·5072349	0·5074798	0·5071392	0·5070658	0·5072299
		− 213	− 206	− 203	− 209	− 208
	g.	979·145	979·142	979·141	979·144	979·143
Kaliána	s.	0·5072321	0·5074770	0·5071361	0·5070629	0·5072270
		− 241	− 234	− 234	− 238	− 237
	g.	979·156	979·153	979·153	979·155	979·154
Meerut	s.	0·5072328	0·5074774	0·5071369	0·5070642	0·5072278
		− 234	− 230	− 226	− 225	− 229
	g.	979·153	979·152	979·150	979·150	979·151
Gesupur	s.	0·5072402	0·5074844	0·5071432	0·5070706	0·5072346
		− 160	− 160	− 163	− 161	− 161
	g.	979·125	979·125	979·126	979·125	979·125
Mohan	s.	0·5072445	0·5074887	0·5071474	0·5070749	0·5072389
		− 117	− 117	− 121	− 118	− 118
	g.	979·108	979·108	979·110	979·109	979·109
Asarori	s.	0·5072573	0·5075013	0·5071605	0·5070879	0·5072517
		+ 11	+ 9	+ 10	+ 12	+ 10
	g.	979·059	979·060	979·059	979·058	979·059
Fatehpur	s.	0·5072347	0·5074786	0·5071373	0·5070653	0·5072290
		− 215	− 218	− 222	− 214	− 217
	g.	979·146	979·147	979·149	979·146	979·147
Kálsi	s.	0·5072391	0·5074823	0·5071415	0·5070691	0·5072330
		− 171	− 181	− 180	− 176	− 177
	g.	979·129	979·133	979·132	979·131	979·131
Rájpur	s.	0·5072722	0·5075158	0·5071748	0·5071027	0·5072664
		+ 160	+ 154	+ 153	+ 160	+ 157
	g.	979·001	979·004	979·004	979·001	979·002

The Orographical Corrections.

The possible effect of the Siwálik and Himalayan ranges has had to be considered at all the stations of this season, with the exception of Kaliána, Meerut and Gesupur.

It was clear that the effect at Nojli and Roorkee would be small, probably inappreciable, so I examined them first.

Orographical Correction at Nojli.

Height 879 feet.

At Nojli the Siwáliks may be looked upon as occupying a quarter-zone of which the inner radius is 24 miles, the outer 32 miles, and the height 2500 feet. The Himalayas may be considered to consist of a mass 6000 feet high subtending an angle of 125° at the station, and extending from 45 miles to an indefinite distance.

Thus the "effect," using this word in the same way as in Chapter II, of the two ranges is

$$\left\{\frac{1}{4}.\frac{1600^2}{2}\left(\frac{1}{24}-\frac{1}{32}\right)+\frac{125}{360}.\frac{5100^2}{2}\left(\frac{1}{45}\right)\right\}\times 0\cdot0001894 = 19\cdot6.$$

The orographical correction is therefore

$$19\cdot6 \times \cdot000035 = 0\cdot00069$$

Orographical Correction at Roorkee.

Height 867 feet.

Within the 35-mile radius the hills, partly Siwálik and partly Himalayan, may be considered to consist of a wedge-shaped block 3000 feet high, subtending an angle of 36° at the pendulum station, and bounded by circles of 26 and 35 miles radii.

Beyond the 35-mile radius the Himalayas may be equated to a mass 6000 feet high occupying 130° of a zone of which the inner radius is 40 miles and the outer of indefinitely great length.

Thus the effect is

$$\left\{\frac{36}{360}\times\frac{2100^2}{2}\times\left(\frac{1}{26}-\frac{1}{35}\right)+\frac{130}{360}\times\frac{5100^2}{2}\times\frac{1}{40}\right\}\times 0\cdot0001894 = 22\cdot6.$$

The orographical correction is therefore

$$22\cdot6 \times 0\cdot000035 = 0\cdot00079.$$

The other stations require more careful treatment as considerable inequalities lie within the 35-mile radius in every case. The analysis is shewn in the following tables:—

Table VI.—Orographical Correction at Hardwár.

Height 949 feet.

(The inequalities within 1 mile of the station may be disregarded.)

No. of Zone	1	2	3	4	5	6	7
Inner radius Outer radius	1 mile 2 miles	2 miles 3 "	3 miles 4 "	4 miles 5 "	5 miles 7 "	7 miles 10 "	10 miles 15 "
Height	*Fraction*	*Fraction*	*Fraction*	*Fraction*	*Fraction*	*Fraction*	*Fraction*
feet 950	0·65	0·60	0·54	0·49	0·53	0·54	0·50
1250	·27	·24	·33	·31	·35	·31	·23
1750	·08	·14	·13	·13	·07	·09	·06
2250		·02		·07	·05	·06	·10
2750							·06
3250							·03
3750							·01
4250							·01
Effect	3·6	2·3	0·9	1·1	0·9	0·8	2·5

No. of Zone	8	9	10
Inner radius Outer radius	15 miles 20 "	20 miles 25 "	25 miles 35 "
Height	*Fraction*	*Fraction*	*Fraction*
feet 950	0·48	0·48	0·47
1500	·23	·13	·09
2500	·05	·09	·10
3000	·15	·12	·14
5000	·09	·18	·14
7000			·05
8500			·01
Effect	3·7	3·5	5·8

Total effect of zones within 35-mile radius = 25·1
Orographical correction = 25·1 × ·000035 = 0·00088

The regions lying beyond the 35-mile radius may be classified as follows:—

Azimuth (from S. by W.)			Mean height
°		°	feet
0	to	130	900
130	„	180	5000
180	„	230	7000
230	„	270	5000
270	„	300	3000
300	„	360	900

The resulting orographical correction is

$$0{\cdot}00092$$

Hence the total orographical correction is $0{\cdot}0009 + 0{\cdot}0009$
$= 0{\cdot}0018$

Mohan.

The immediate surroundings may be taken into account by considering that the station is on the vertex of a cone, the base of which has a radius of ½ mile, and the sides a slope of 1 in 6.

The orographical correction is the difference between the attraction of this cone and that of a cylinder of equal height on the same base.

The attraction of the cylinder $= k\left(h + r - \sqrt{r^2 + h^2}\right)$

The attraction of the cone $= k\left(h - \dfrac{h^2}{\sqrt{r^2 + h^2}}\right)$

Difference $= k\,r\left(1 - \dfrac{r}{\sqrt{r^2 + h^2}}\right)$

Here $h = \dfrac{r}{6}$; $r = 1320$ feet; $k = 0{\cdot}000035$

Therefore the difference of attractions

$$= 1320\ (1 - 0{\cdot}9864) \times 0{\cdot}000035$$
$$= 0{\cdot}00063$$

Table VII.—Orographical Correction at Mohan. Height 1660 feet.

No. of Zone	1	2	No. of Zone	3	4	5	6	7
Inner Radius Outer Radius	1320 feet 2640 „	2640 feet 5280 „	Inner Radius Outer Radius	1 mile 2 miles	2 miles 3 „	3 miles 5 „	5 miles 7 „	7 miles 10 „
Height	*Fraction*	*Fraction*	Height	*Fraction*	*Fraction*	*Fraction*	*Fraction*	*Fraction*
feet 1400	0·02	0·12	*feet* 900			0·22	0·33	0·37
1560	·46	·40	1250	0·33	0·40	·16	·11	·08
1800	·37	·29	1500	·25	·09	·08	·04	·22
2100	·15	·19	2250	·23	·39	·27	·33	·26
			2700	·19	·12	·37	·19	·07
Effect	7·5	5·2	Effect	16·5	5·3	6·8	2·9	1·6

Table VII.—Orographical Correction at Mohan—(Continued).

No. of Zone	8	9	10	11
Inner Radius Outer Radius	10 miles 15 „	15 miles 20 „	20 miles 25 „	25 miles 35 „
Height	*Fraction*	*Fraction*	*Fraction*	*Fraction*
feet 900	0·39	0·42	0·45	0·44
1660	·32	·29	·27	·13
2500	·29	·06		
3000		·17	·09	·13
5000		·05	·11	·16
7000		·01	·08	·12
9000				·02
Effect	1·3	2·3	3·7	7·1

Total effect of zones within 35-mile radius = 60·2
Orographical correction = 60·2 × 0·000035 = 0·00211

The masses lying beyond the 35-mile radius may be classified as follows :—

Azimuth (From S. by W.)			Mean Height
			feet
0°	to	130°	900
130	„	190	5000
190	„	250	7000
250	„	280	5000
280	„	305	3000
305	„	360	900

The resulting orographical correction is

0·00075

Hence the total orographical correction is

$$0{\cdot}00063 + 0{\cdot}00211 + 0{\cdot}00075 = 0{\cdot}00349$$

Table VIII.—Orographical Correction at Asarori.

Height 2467 feet.

No. of Zone	1	2	3	4	5
Inner Radius Outer Radius	500 feet 1000 „	1000 feet 1700 „	1700 feet 2640 „	½ mile 1 „	1 mile 2 miles
Height	*Fraction*	*Fraction*	*Fraction*	*Fraction*	*Fraction*
feet 1950					0·14
2250				0·30	·26
2350	0·10	0·06	0·07		
2450	·41	·28	·21	·43	·33
2550	·41	·40	·40		
2650	·08	·20	·26	·18	·19
2750		·06	·06		
2850				·09	·08
Effect	4·1	3·4	2·0	3·3	3·1

No. of Zone	6	7	8	9	10	11	12	13
Inner Radius Outer Radius	2 miles 3 „	3 miles 5 „	5 miles 7 „	7 miles 10 „	10 miles 15 „	15 miles 20 „	20 miles 25 „	25 miles 35 „
Height	*Fraction*	*Fraction*	*Fraction*	*Fraction*	*Fraction*	*Fraction*	*Fraction*	*Fraction*
feet 900				0·07	0·24	0·31	0·38	0·45
1250			0·06	·12				
1500					·29	·30	·22	·12
1750		0·27	·26	·37				
2250	0·77	·56	·54	·36	·12	·06		
2700	·23	·17	·14	·08	·06	·03		
3250					·17	·04	·07	·09
5000					·10	·12	·15	·20
7000					·02	·12	·15	·12
8500						·02	·03	·02
Effect	0·9	6·0	1·0	1·1	6·4	8·1	5·9	6·0

Total effect of zones within 35-mile radius = 51·3
Orographical correction = 51·3 × 0·000035 = 0·0018

The outer regions may be divided up in the same way as in the case of Mohan, but the height of the station being greater by 800 feet the resulting correction is slightly different; its value is

0·0006

Hence total orographical correction is 0·0018 + 0·0006
= 0·0024.

Table IX.—Orographical Correction at Fatehpur.
Height 1434 feet.

(Up to 3 miles from the station the inequalities are not large enough to be taken into account.)

No. of Zone	1	2	3	No. of Zone	4	5	6	7
Inner Radius Outer Radius	3 miles 5 „	5 miles 7 „	7 miles 10 „	Inner Radius Outer Radius	10 miles 15 „	15 miles 20 „	20 miles 25 „	25 miles 35 „
Height	*Fraction*	*Fraction*	*Fraction*	Height	*Fraction*	*Fraction*	*Fraction*	*Fraction*
feet 1300	0·14	0·07	0·17	*feet* 900	0·07	0·24	0·33	0·32
1700	·65	·65	·36	1600	·34	·13	·10	·15
2250	·13	·15	·16	2500	·11	·09	·04	·02
2500		·03	·14	3000	·25	·17	·14	·09
2700	·08	·10	·08	5000	·15	·16	·17	·09
3500			·05	7000	·08	·19	·16	·23
4500			·03	9000		·02	·06	·10
5500			·01					
Effect	3·6	1·8	4·6	Effect	16·0	15·8	10·6	15·1

Total effect of zones within 35-mile radius = 67·5
Orographical correction = 67·5 × 0·000035 = 0·0024

The outer regions may be estimated as follows:—

Azimuth (From S. by W.)		Height *feet*
0° to 120°	... ...	900
120 „ 200	... ...	5000
200 „ 260	... ...	7000
260 „ 315	... ...	4000
315 „ 360	... ...	900

The resulting orographical correction is

0·0009

Hence total orographical correction is 0·0024 + 0·0009
= 0·0033

Kalsi.

The station is situated about 30 yards from the outer edge of a shelf of land below which flows the Jumna and above which stands the outer range of the Himalayas.

An approximation to the masses within a radius of ¼ mile may be made by assuming that the station is 100 feet from the edge of a cliff 100 feet high, and that if circles be described with radii of 100 feet and ¼ mile respectively, half the land enclosed between them will be at the same level as the station and half 100 feet below it.

The orographical correction on account of this half zone is

0·00065

From ¼ mile to 35 miles the analysis has been made in the usual way.

Table X.—Orographical Correction at Kálsi.

Height 1684 feet.

No. of Zone	1	No. of Zone	2	3	4	5
Inner Radius Outer Radius	¼ mile 1 "	Inner Radius Outer Radius	1 mile 3 miles	3 miles 5 "	5 miles 7 "	7 miles 10 "
Height	*Fraction*	Height	*Fraction*	*Fraction*	*Fraction*	*Fraction*
feet 1584	0·67	*feet* 1550	0·27	0·22	0·24	0·26
1840	·17	1850	·23	·09	·10	·07
2500	·16	2500	·34	·26	·15	·13
		3500	·10	·21	·15	·12
		4500	·06	·16	·17	·18
		5550		·05	·14	·13
		6500		·01	·05	·10
		7200				·01
Effect	29·1	Effect	64·6	38·5	27·5	26·0

Table X.—Orographical Correction at Kálsi—(Continued).

No. of Zone	6	7	8	9
Inner Radius Outer Radius	10 miles 15 „	15 miles 20 „	20 miles 25 „	25 miles 35 „
Height	*Fraction*	*Fraction*	*Fraction*	*Fraction*
feet 900		0·02	0·17	0·30
1400	0·26	·27	·12	·12
2500	·11	·14	·08	·02
3000	·19	·15	·14	·08
5000	·26	·12	·17	·16
7000	·17	·21	·24	·21
9000	·01	·09	·08	·10
10500				·01
Effect	26·7	19·9	12·6	14·7

Total effect of zones within 35-mile radius ... = 259·6
Orographical correction = 259·6 × 0·000035 = 0·00909.

The regions outside the 35-mile radius may be classified as follows:—

Azimuth (From S. by W.)	Height
° °	*feet*
0 to 125	900
125 „ 195	5000
195 „ 255	7000
255 „ 295	5000
295 „ 340	3000
340 „ 360	900

The resulting orographical correction is 0·00081

Hence the total orographical correction is 0·00065 + 0·00909 + 0·00081

= 0·01055

Table XI.—Orographical Correction at Rájpur.
Height 3321 feet.

(Up to a radius of 500 feet the inequalities may be disregarded).

No. of Zone	1	2	3	No. of Zone	4	5	No. of Zone	6	7
Inner Radius Outer Radius	500 feet 1000 „	1000 feet 1700 „	1700 feet 2640 „	Inner Radius Outer Radius	½ mile 1 „	1 mile 2 miles	Inner Radius Outer Radius	2 miles 3 „	3 miles 5 „
Height	*Fraction*	*Fraction*	*Fraction*	Height	*Fraction*	*Fraction*	Height	*Fraction*	*Fraction*
feet 3050		0·02	0·15	*feet* 2800	0·15	0·30	*feet* 2300	0·07	0·17
3150	0·01	·12	·31	3150	·43	·20	2900	·37	·24
3250	·25	·51	·26	3600	·33	·11	3700	·17	·11
3350	·70	·35	·11	4500	·09	·21	4500	·20	·09
3450	·04		·05	5500		·17	5500	·14	·16
3550			·06	6500		·01	6500	·05	·20
3650			·06				7200		·03
Effect	2·0	1·5	3·5	Effect	18·2	61·6	Effect	25·8	45·8

No. of Zone	8	9	10	11	12	13
Inner Radius Outer Radius	5 miles 7 „	7 miles 10 „	10 miles 15 „	15 miles 20 „	20 miles 25 „	25 miles 35 „
Height	*Fraction*	*Fraction*	*Fraction*	*Fraction*	*Fraction*	*Fraction*
feet 900					0·06	0·22
1500			0·20	0·24	·24	·14
2500	0·43	0·40				
3000			·27	·23	·22	·12
5000	·28	·29	·21	·33	·23	·21
7000	·27	·25	·23	·20	·21	·19
8500	·02	·06				
9000			·09		·04	·11
10500						·01
Effect	28·7	25·0	22·8	7·2	5·7	9·4

Total effect of zones within 35-mile radius = 257·2
Orographical correction = 257·2 × 0·000035
= 0·00900.

The outer regions may be classified thus :—

Azimuth (From S. by W.) ° °	Height feet
0 to 120	900
120 „ 180	5000
180 „ 250	9000
250 „ 290	4000
290 „ 320	3000
320 „ 360	900

The resulting orographical correction is 0·00088

Hence the total orographical correction is 0·00900 + 0·00088
= 0·00988

Dehra Dún.

The maps of the Dún having all been contoured the opportunity of recomputing the orographical correction for Dehra Dún was favourable, and this has therefore been done. The value which has been used in Chapter II depends, up to a radius of 30 miles, on the calculation made in Vol. V. *Op. G. T. S.* p. [177], though for the outer regions I substituted my own figures. It is desirable that the orographical correction of all the stations in and about the Dún be based on the same estimates of height, so that they may be at least consistent, and, as there was so large a divergence between my heights and those of Vol. V in the outer zones, it seemed probable that there might be some discrepancy in the inner ones also.

Table XII.—Orographical Correction at Dehra Dún. Height 2241 feet.

(Up to a radius of 3 miles the inequalities may be disregarded).

No. of Zone	1	2	3	No. of Zone	4	5	6	7
Inner Radius Outer Radius	3 miles 5 „	5 miles 7 „	7 miles 10 „	Inner Radius Outer Radius	10 miles 15 „	15 miles 20 „	20 miles 25 „	25 miles 35 „
Height	*Fraction*	*Fraction*	*Fraction*	Height	*Fraction*	*Fraction*	*Fraction*	*Fraction*
feet 1800	0·20	0·26	0·27	*feet* 900		0·12	0·23	0·31
2100	·37	·18	·10	1500	0·29	·32	·21	·14
2350	·16	·10	·11	2500	·20	·10	·05	
2900	·24	·21	·11	3000	·13	·06	·09	·13
3600	·03	·19	·11	5000	·18	·17	·27	·17
4500		·06	·11	7000	·17	·18	·13	·18
5500		·00	·10	8500	·03	·05	·02	·07
6500			·08					
7200			·01					
Effect	2·7	4·5	15·1	Effect	21·1	12·7	6·1	9·3

Total effect of zones within 35-mile radius = 71·5
Orographical correction = 71·5 × 0·000035
= 0·00250

The regions outside the 35-mile radius may be analysed in the same way as in Chapter II. There the inner radius was 30 miles, here it is 35 miles, the value of the correction there obtained must consequently be multiplied by $\frac{30}{35}$. It becomes therefore

0·00111

Hence the total orographical correction is

0·0036

The value adopted in Chapter II was

0·0041

The two values thus agree satisfactorily.

Table XIII.—Abstract of Final Results.

Station	Latitude	Height	Observed g	$g\frac{2h}{R}$	$g\frac{3}{4}\frac{h}{R}$	O	Value at sea level g_0''	γ_0	$g_0'' - \gamma_0$
	° ′ ″	*feet*							
Hardwár ...	29 56 29	949	979·122	+0·089	−0·033	+0·002	979·180	979·294	−0·114
Roorkee ...	29 52 20	867	979·129	+0·081	−0·030	+0·001	979·181	979·288	−0·107
Nojli ...	29 53 28	879	979·143	+0·082	−0·031	+0·001	979·195	979·290	−0·095
Kaliána ...	29 30 55	810	979·154	+0·076	−0·028	0·00	979·202	979·260	−0·058
Meerut ...	29 0 26	734	979·151	+0·069	−0·026	0·00	979·194	979·221	−0·027
Gesupur ...	28 33 2	691	979·125	+0·065	−0·024	0·00	979·166	979·186	−0·020
Mohan ...	30 10 53	1660	979·109	+0·155	−0·058	+0·003	979·209	979·313	−0·104
Asarori	30 14 25	2467	979·059	+0·231	−0·087	+0·002	979·205	979·317	−0·112
Fatehpur ...	30 25 53	1434	979·147	+0·132	−0·049	+0·003	979·233	979·333	−0·100
Kálsi ...	30 31 8	1684	979·131	+0·158	−0·059	+0·011	979·241	979·339	−0·098
Rájpur ...	30 24 12	3321	979·002	+0·311	−0·117	+0·010	979·206	979·330	−0·124

CHAPTER VI.

The Accuracy of the observations.

There are two convenient ways of determining the probable error of the reduced time of vibration of a pendulum. These have already been mentioned in Chapter I.

I may here repeat that if ρ be the probable error of one complete determination of the time of vibration of any pendulum, that is to say, of the result of a night and a day observation preceded and followed by time determinations; and if for any series of observations the differences between the individual pendulums and the mean pendulum, the mean differences, and the residuals be formed as in Table III of Chapter III; and if all the residuals of the series be squared and summed, then

$$\rho = 0{\cdot}6745 \sqrt{\frac{[\mathrm{v\,v}]}{3(n-1)}}$$

where n is the number of sets of observations.

Also since there are four pendulums, the probable error of one determination of the time of vibration of the mean pendulum is

$$\rho_0 = \frac{\rho}{2}$$

Secondly if there are two or more sets of observations at each station, and if the differences between the several values of the time of vibration of the mean pendulum and the station-means be called v′, then, if there are n stations and m sets of observations in all, the probable error of one determination of the time of vibration of the mean pendulum is

$$\mu_0 = 0{\cdot}6745 \sqrt{\frac{[\mathrm{v'\,v'}]}{m-n}}$$

It will be seen that the same words are used to define ρ_0 and μ_0 but they are not identical quantities: I shall call the two ways of computing the above probable error A and B respectively and the results ρ_0 and μ_0

In Chapter II the quantities necessary for computing ρ_0 were not given, they are shewn in the following table:—

Table I.—Differences between Individual Pendulums and Mean Pendulum.

Station	Date	137	v	138	v	139	v	140	v
	1904								
Dehra Dún ...	Jan. 25-26	72	4	2485	10	898	7	1658	1
	" 26-27	76	8	2484	11	895	10	1663	6
	" 29-30	73	5	2493	2	903	2	1663	6
	Feb. 3- 4	69	1	2491	4	903	2	1656	1
	" 4- 5	74	6	2491	4	904	1	1660	3
	" 5- 6	68	0	2489	6	903	2	1652	5
Madras ...	Mar. 3- 4	41	27	2508	13	905	0	1645	12
	" 4- 5	80	12	2483	12	907	2	1656	1
	" 6- 7	45	23	2507	12	913	8	1637	20
	" 7- 8	62	6	2493	2	911	6	1644	13
Colaba ...	Mar. 16-17	68	0	2495	0	903	2	1661	4
	" 17-18	74	6	2496	1	904	1	1666	9
	" 20-21	64	4	2505	10	905	0	1664	7
	" 21-22	72	4	2500	5	912	7	1660	3
Mussooree (*Dunseverick*) ...	Ap. 22-23	64	4	2501	6	909	4	1653	4
	" 23-24	70	2	2497	2	005	0	1661	4
	" 25-26	66	2	2496	1	907	2	1654	3
	" 26-27	68	0	2495	0	909	4	1653	4
Mussooree (*Camel's Back*)	May 16-17	69	1	2495	0	897	8	1665	8
	" 17-18	81	13	2500	5	919	14	1663	6
	" 18-19	50	18	2498	3	896	9	1650	7
Dehra Dún	May 27-28	76	8	2490	5	909	4	1656	1
	" 28-29	84	16	2491	4	904	1	1670	13
	June 2- 3	58	10	2504	9	906	1	1656	1
	" 3- 4	68	0	2494	1	901	4	1660	3
	" 4- 5	73	5	2497	2	909	4	1660	3
Mean		68	...	2495	...	905	...	1657	...

The sums of the squares of the residuals are for the different pendulums :—

Pendulum	137	138	139	140
[v v]	2611	1082	747	1372

The number of sets is 26.

Hence $\rho = 0 \cdot 6745 \sqrt{\frac{5812}{3\ (25)}}$

$= \pm 5 \cdot 9$

and $\rho_0 = \pm 3 \cdot 0$

Employing method B we have

Table II.

Station	No. of Sets	v′ v′
Dehra Dún ...	6	47
Madras ...	4	117
Colaba ...	4	167
Mussooree (*Dunseverick*) ...	4	78
Mussooree (*Camel's Back*)...	3	233
Dehra Dún ...	5	315
Total ...	26	957

The number of stations is 6.

Hence $$\mu_0 = 0{\cdot}6745 \sqrt{\frac{957}{26-6}} = \pm\ 4{\cdot}7.$$

The number of stations is small and it would be rash to generalise from the values of ρ_0 and μ_0 derived from them. I therefore go on to examine the results of the next season's work.

The Season 1904-05.

In Table III of Chapter III the quantities necessary for computing ρ_0 are given.

There are 48 sets of observations and the following values of [vv] are found by squaring and summing the quantities v.

Pendulum	137	138	139	140
[vv]	1277	2037	3812	4820

Hence $$\rho = 0{\cdot}6745 \sqrt{\frac{11946}{3 \times 47}} = \pm\ 6{\cdot}1$$

and $$\rho_0 = \pm\ 3{\cdot}1$$

In the computation of μ_0 by method B we have the following series of values :—

Table III.

Station		No. Sets	[v′ v′]
Dehra Dún (Room)	...	4	155
,, (Tent)	...	2	85
Cuttack	...	3	35
Chatra	...	3	165
Kisnapur	...	2	0
Jalpaiguri	...	3	163
Kesarbari	...	(1)	...
Ramchandpur	...	3	817
Siliguri	...	4	262
Darjeeling	...	3	6
Kurseong	...	4	157
Sandakphu	...	3	5
Dehra Dún (Room)	...	3	45
Dehra Dún (Tent)	...	3	17
Totals	...	40	1912

The number of stations is 13.

Hence $$\mu_0 = 0{\cdot}6745 \sqrt{\frac{1912}{40-13}} = \pm\ 5{\cdot}7$$

By method A we had $$\rho_0 = \pm\ 3{\cdot}1$$

As in the case of the observations ending in June 1904, we have μ_0 larger than ρ_0.

The difference shows that the cause of a large proportion of the total error does not affect the differences between the individual pendulums and the mean pendulum in any set, but produces differences from set to set.

This cause is probably twofold, namely,

(1) Differences between the temperatures of the pendulums and the temperatures recorded by the thermometers,
(2) Variations of clock rate.

During the hours of observation when the temperature is being constantly watched and to some extent controlled, it is probable that the difference between the real temperature of each pendulum and that recorded by the thermometer is fairly constant, but the amount of this difference will depend on the conditions antecedent to the commencement of the observation, and these conditions will differ from day to day according to the state of the weather.

Also if the clock rate is constant during the hours of observation no discrepancy between the actual rate and the rate adopted for the period of 24 hours will affect the differences between the individual pendulums and the mean pendulum, but it might well occur, when the temperature is variable, that the mean of the actual rates during the night and day observations would differ to some extent from the 24-hourly rate, and so produce discrepancies from set to set. Besides this the observed daily rates are no doubt burdened with a certain amount of error.

Both cause (1) and cause (2) should have had less influence at stations where suitable observing rooms were available than at those where the conditions were less favourable. To examine this I have computed the probable errors by both methods for the following stations of the season 1904-05:—Dehra Dún (Room), Jalpaiguri, Darjeeling, Kurseong, Sandakphu and Dehra Dún (Room).

The results are:—

By method A ... ... $\rho = \pm 6{\cdot}8$

Whence ... ... $\rho_0 = \pm 3{\cdot}4$

By method B ... ... $\mu_0 = \pm 4{\cdot}2$

The former results were respectively

$$\rho_0 = \pm 3{\cdot}1 \text{ and } \mu_0 = \pm 5{\cdot}7$$

There is therefore a considerable diminution of the discrepancy, though it is clear that even in the rooms the causes discussed had a considerable effect.

If we call the probable error due to these causes r

$$r = \sqrt{\mu_0^2 - \rho_0^2}$$

And we have

(1). For the observations of Chapter II ... $r = \pm 3{\cdot}6$

(2). For the observations of Chapter III
(a) when all the stations are included ... $r = \pm 4{\cdot}8$
(b) when only the stations with rooms are included ... ... $r = \pm 2{\cdot}4$

The large values of v at Madras and at the Camel's Back station Mussooree are to be chiefly attributed to want of experience on the part of the observer and to unsteady temperature.

The large values of the same quantity at Ramchandpur, and at Dehra Dún in May 1905, and the very large value of [v′v′] at Ramchandpur, are worthy of attention.

With regard to Dehra Dún it is possible that these discordances were due to earth tremors caused by the after-shocks of the great Kangra Earthquake of April 4, 1905. Dehra Dún lies very near, in fact almost within the epifocal region* of that earthquake; its effects there were disastrous, and a great number of small after-shocks were no doubt taking place during the month of May. The absence of any notable irregularity during the observations in the tent (May 12th – 15th) does not prove that the discrepancies of 18th and 19th were not due to tremors, for there may accidentally have been a quiet period while the first series of observations was in progress.

At Ramchandpur the pendulums were swung in a hut built under a mango tree. This position was chosen for the sake of the protection from the sun that the tree afforded, but it has since occurred to me that the neighbourhood of a large tree is not a good place. If there is any wind the ground round the tree must be subject to many vibrations communicated by the branches, through the trunk, to the roots. I have unfortunately no note as to whether there was or was not much wind during my stay at Ramchandpur.

The Season 1905-06.

Using the values of v in Table III of Chapter IV we have after squaring and summing,

Pendulum	137	138	139	140
[vv]	1870	1005	1338	860

The total number of sets is 46.

Hence $\rho = 0 \cdot 6745 \sqrt{\frac{4573}{3 \times 45}}$

$= \pm \; 3 \cdot 9$

and $\rho_0 = \pm \; 2 \cdot 0$

Now taking the differences between the station-means and the means of the single sets we have

Table IV.

Station	No. of sets	[v′ v′]
Dehra Dún	3	114
Simla	3	218
Kálka	(1)	...
Ludhiána	4	27
Mián Mir	3	17
Ferozepore	3	17
Pathánkot	3	145
Montgomery	3	32
Dera Ghází Khan ...	3	146
Multán	3	162
Jacobabad	3	3
Sibi	2	13
Mach	2	41
Quetta	3	26
Dehra Dún	4	27
Totals ...	42	988

* *Vide* Prof. Omori's map in the "*Publications of the Earthquake Investigation Committee*" No. 24, Tokyo, Japan, 1907.

The number of stations is 14.

Hence
$$\mu_0 = 0{\cdot}6745\sqrt{\frac{988}{42-14}}$$
$$= \pm\ 4{\cdot}0$$

As in the previous series of observations, μ_0 is larger than ρ_0.

In the present case the quantity which has been called r has the value

$$\pm\ 3{\cdot}5$$

The Season 1906-07.

Proceeding as before, but omitting from consideration the observations made at the beginning of the season at Dehra Dún, on account of the change in Pendulum No. 137 that took place just after the observations there, we obtain for this season the following results:—

Pendulum	137	138	139	140
[vv]	783	342	438	604

The total number of sets is 33.

Hence
$$\rho = 0{\cdot}6745\sqrt{\frac{2167}{96}}$$
$$= \pm\ 3{\cdot}2$$

and
$$\rho_0 = \pm\ 1{\cdot}6$$

Now using method B, we have

Table V.

Station		No. of sets	[v′ v′]
Dehra Dún	...	3	49
Hardwár	...	3	5
Roorkee	...	4	27
Nojli	...	3	49
Kaliána	...	4	23
Meerut	...	3	1
Gesupur	...	3	11
Mohan	...	2	8
Asarori	...	2	1
Fatehpur	...	2	18
Kálsi	...	2	18
Rájpur	...	2	1
Dehra Dún	...	3	9
Totals	...	36	220

The number of stations is 13.

Hence
$$\mu_0 = 0{\cdot}6745\sqrt{\frac{220}{36-13}}$$
$$= \pm\ 2{\cdot}1$$

The good accordance between the two values $\pm$ 2·1 and $\pm$ 1·6 shows that during this season the cause of discrepancies between sets has been to a large extent overcome. This may be safely attributed to the introduction of the thermometer in the dummy pendulum for measuring the temperature of the pendulums. There was no change in the clock nor in the instruments used in the time observations, and the rooms occupied were not superior to those of the season 1905-06; we may conclude therefore that of the two possible causes mentioned on p. 177, the first was the more potent.

The quantity r for this season

$$= \sqrt{2{\cdot}1^2 - 1{\cdot}6^2}$$

$$= \pm 1{\cdot}4$$

The investigation of the errors has so far taken into consideration only the discrepancies between the observed values of the time of vibration at the several stations. When we come to consider the differences between these times and those observed at the Base station, Dehra Dún, there are other sources of error to be taken into account, for there are several errors which are constant throughout the whole of the observations at a station, but which differ from station to station. I enumerate some of them here.

1. Errors in the flexure correction.
2. Errors in the corrections of the thermometers.
3. Errors in the corrections of the barometer and hygrometer.
4. Error in the constant of the temperature correction.
5. Error in the constant of the density correction.
6. Errors due to changes in the lengths of the pendulums.

I shall discuss them *seriatim.*

1. The flexure correction.

An examination of the observed values of the flexure correction will show that the p.e. of the adopted mean seldom exceeds $\pm$ 0·5. I shall take its value to be $\pm$ 1·0. There seems no reason to suppose that the error of the determination is greater when the flexure is large than when it is small, at least within the moderate variations actually encountered. At some few stations where the flexure was unsteady, owing to the cement in the pillar not having hardened when the observations began, there will no doubt have been a greater liability to error, but these cases were rare and need not be considered further.

2. The correction to the thermometer readings.

All the thermometers used for determining the temperatures of the pendulums have had their corrections determined on three separate occasions at the National Physical Laboratory at Kew. On the first two occasions the readings were made to 0·05 of a degree centigrade, and on the third occasion to 0·02. The determinations agree well with one another and I do not think that the difference of two corrected readings is likely to have a p.e. from this cause, of more than $\pm 0^\circ{\cdot}02$. It is to be remarked that we are concerned with differences of temperature only, not with absolute temperatures.

If the p. e. of the difference of temperature be $\pm$ 0°·02, that of the difference of the times of vibration will be

$$\pm 0{\cdot}02 \times 49 = \pm 1{\cdot}0.$$

3. The corrections to the barometer and hygrometer.

These may be entirely neglected. An error of 1 millimetre in the height of the barometer has no effect on the correction to the time of vibration, and errors in the hygrometer are of still less importance.

4. The constant of the temperature correction.

The value of this constant was determined both at Potsdam and at Kew: the results are given on p. 5 of this paper. The value which has been used for all the reductions is 49, and from the figures on p. 5 we may estimate that the p.e. of this value is not greater than $\pm$ 0·2. If C be the difference between the average temperature of the pendulums at any station and the mean of the temperatures at Dehra Dún during the opening and closing sets of observations, the p.e. of the difference between the reduced times of vibration will be

$$\pm\ 0{\cdot}2 \times C.$$

The error will be different for each station; but it will be sufficient here to find its average value and its extreme value for each season.

In the season which ended in June 1904 the mean of the temperatures at Dehra Dún was 21°·0, the average of the temperatures at the other stations 20°·8, and the temperature which differed most from 21°·0 was that at Mussooree (Camel's Back), where it was 14°·0.

Thus the average p.e. was $\pm$ 0·04
And the greatest p.e. was $\pm$ 1·4.

In the season 1904-05 the mean of the temperatures at Dehra Dún was 22°·7, the average at the other stations 17°·6, and the lowest 8°·3 at Sandakphu.

Hence the average p.e. was $\pm$ 1·0
And the greatest p.e. was $\pm$ 2·9

For the season 1905–06 the figures were:—

At Dehra Dún	23°·5	
Average of field stations ...	16 ·8	
Extreme	10 ·8	(At Simla)

Hence the average p.e. was $\pm$ 1·3
And the extreme p.e. was $\pm$ 2·5.

For the season 1906-07 the temperatures were:—

At Dehra Dún	20°·8	
Average of fields stations ...	18 ·4	
Extreme	15 ·1	(At Nojli)

Hence the average p. e. was $\pm$ 0·5
And the extreme p. e. was $\pm$ 1·1

For any ordinary station, then, a liberal estimate of the p. e. of the difference between the reduced times of vibration due to uncertainty in the temperature constant will be $\pm$ 1·0.

5. The constant of the density correction.

The value of this constant also was determined both at Kew and at Potsdam. The means of the two sets of values (vide p. 4) differ by 1·7 per cent. The Potsdam values have been used throughout, and from the probable errors given that of the mean is $\pm$ 1·8 or 0·3 per cent.

A reasonable assumption will be that the p. e. does not exceed 1·0 per cent.

On this account, then, the p. e. of the difference between the times of vibration at Dehra and at any other station is $\pm$ 5·95 $\times$ (Density at Dehra—Density at Station).

The average density at Dehra is about 0·848, and at ordinary stations in the plains of India it is about 0·930. The p. e. corresponding to this difference is

$$\pm 0{\cdot}5$$

The lowest density so far met with was that at Sandakphu, namely 0·626.

The maximum p. e. therefore was $\pm$ 1·3

I have adopted $\pm$ 0·8 as the normal value of this probable error.

6. Changes in the lengths of the pendulums.

Minute changes of an accidental character such as would be occasioned by slight movements of the agates in their bearings, or by particles of dust or moisture adhering to the surface of the pendulums have been instrumental in forming the discrepancies whence ρ_0 and μ_0 have been computed and need not be further considered. Systematic changes of individual pendulums with reference to the others have also had their effect on ρ_0, and when considerable they have been allowed for, as in the case of Pendulum No. 140 during the season 1904-05, and of Pendulum No. 137 in November 1906, but such changes, as well as others affecting all the pendulums similarly, will produce an uncertainty as to the proper value of the time of vibration at the Base station with which comparison should be made. If, for instance a change of x in the time of vibration took place between the opening and the closing observations, the question is, "When did the change take place?" If it was a slow progressive change then the quantity x should be distributed evenly over the stations; but if the change took place suddenly, say after the first field station, then that station should receive no correction and all the others should receive a correction of x.

The time of vibration at Dehra Dún has been taken to be the mean of the observed times before and after the field season*, and the discrepancies between these times afford a means of estimating the uncertainty arising from changes in the pendulums.

The times in question were :—

	Time of vibration	Diff.
	s	
January and February 1904	0·5072528	− 9
May and June 1904	2519	
November 1904 (Room)	2522	−13
May 1905 ,, ...	2509	
November 1904 (Tent)	2504	− 2
May 1905 ,, ...	2502	
November 1905	2506	+ 9
April 1906	2515	
November 1906	2508	− 3
April 1907	2505	

These differences do not depend wholly on changes in the pendulums and it is only possible to form an idea of the uncertainty due to this cause. If we treat each pair of values as if it consisted of two observations of the same thing, the difference being an accidental error, the average p. e. of the mean of a pair is

$$\pm 2{\cdot}8.$$

I shall adopt $\pm$ 3·0 as the value of the p. e. due to changes in the pendulums, *except in the season 1904-05 for which I shall assign* $\pm$ 4·0.

---

* In two cases special corrections were first applied.

It has been pointed out that the error represented by *r* will be in part due to errors in the determination of the clock rate. The amount of this error must therefore be examined.

In the following tables I give an example of the time observations at a station :—

Station Gesupur.

Table VI.—Dislevelment of Transit Axis.

Date	March 3rd	March 4th	March 5th	March 6th
At Beginning	+ 3″·7	+ 3″·3	+ 2″·5	+ 3″·4
At End	+ 4·3	+ 4·3	+ 5·0	+ 4·2
Mean	+ 4·0	+ 3·8	+ 3·8	+ 3·8

Table VII.—Deviation in Azimuth.

Star	March 3rd	March 4th	March 5th	March 6th
ε Ursae Minoris (S. P.)	West 13″·2	West 13″·7	West 16″·5	West 18″·4
δ Ursae Minoris (S. P.)	„ 14·4	„ 15·6	„ 17·2	„ 19·2
51 (Hev.) Cephei ...	„ 15·0	„ 19·1	„ 20·3	„ 22·2
Mean	„ 14·2	„ 16·1	„ 18·0	„ 19·9

Table VIII.—Abstract of Corrected Times of Transit and Deduced Clock Rates at Gesupur.

Star	Zenith Distance	Aspect	Times of Transit				Clock Rate		
			1907 3rd March	Mar. 4th	Mar. 5th	Mar. 6th	3rd—4th	4th—5th	5th—6th
	° ′		h m s	s	s	s	s	s	s
ι Aurigae	4 28	N	4 52 11·95	8·91	5·87	2·90	− 3·04	− 3·04	− 2·97
1572	4 24	S	5 3 42·48	39·37	36·32	33·43	− 3·11	− 3·05	− 2·89
μ Aurigae	9 50	N	8 19·62	16·58	13·59	10·53	− 3·04	− 2·99	− 3·06
1627	4 44	N	13 20·29	17·19	14·23	11·21	− 3·10	− 2·96	− 3·02
1648	0 41	S	16 24·85	21·86	18·73	15·79	− 2·99	− 3·13	− 2·94
β Tauri	0 1	S	21 40·73	37·59	34·55	31·61	− 3·14	− 3·04	− 2·94
1709	0 34	N	25 2·08	58·88	55·87	52·97	− 3·20	− 3·01	− 2·90
1723	3 35	N	27 56·39	53·25	50·25	47·30	− 3·14	− 3·00	− 2·95
ζ Tauri	7 28	S	33 21·19	18·08	15·01	12·09	− 3·11	− 3·07	− 2·92
1801	5 23	S	38 0.00	53·58	50·62	47·54	...	− 2·96	− 3·08
1824	10 57	N	43 39·84	36·72	33·64	30·69	− 3·12	− 3·08	− 2·95
1863	0 57	S	48 54·01	41·91	38·83	35·90	− 3·10	− 3·08	− 2·93
σ Aurigae	8 39	N	54 38·92	35·72	32·58	29·63	− 3·20	− 3·14	− 2·95
η Geminorum	6 1	S	6 10 32·00	...	25·75	22·76	...	...	− 2·99
2021	6 42	N	13 56·63	33·51	50·52	47·54	− 3·12	− 2·99	− 2·98
μ Geminorum	5 59	S	18 36·17	33·11	30·08	27·08	− 3·06	− 3·03	− 3·00
2084	8 0	S	23 41·08	37·91	34·83	31·95	− 3·17	− 3·08	− 2·88
2130	2 58	N	30 0·00	13·94	10·95	8·01	...	− 2·99	− 2·94
51 Aurigae	10 55	N	33 29·17	26·06	22·99	20·15	− 3·11	− 3·07	− 2·84
ε Geminorum	3 20	S	39 0·00	25·71	22·64	19·75	...	− 3·07	− 2·89
σ Geminorum	5 31	N	47 55·77	52·67	49·62	46·67	− 3·10	− 3·05	− 2·95
2254	3 3	S	50 51·83	48·67	45·60	42·74	− 3·16	− 3·07	− 2·86
			Mean Rate				− 3·11	− 3·04	− 2·95
			Correction on account of Change in R. A.				+ 0·02	+ 0·02	+ 0·02
			Final Mean Rate				− 3·09	− 3·02	− 2·93
			Probable Error of Mean Rate ...				±0·009	±0·007	±0·009

The number of stars observed may be thought unnecessarily large but when the plan is followed of observing the same stars each night, a few passing clouds might render the whole programme useless unless the observations extended over a considerable time.

The p. e. of the clock rate being about $\pm 0^s{\cdot}01$, that of the reduced time of vibration will be

$$\pm 59 \times 10^{-7} \times 0{\cdot}01 = \pm 0{\cdot}06 \times 10^{-7}$$

This value should be slightly increased on account of the p. e. of the level correction, any uncertainty in which affects the time of transit of all the stars in the same way. No increase is necessary on account of uncertainty in the azimuthal deviation, for the programme is always divided equally between stars north and south of the zenith so that a cancelment of errors is brought about.

The value $\pm 0{\cdot}8 \times 10^{-7}$ may be assigned to the total p. e. on account of errors in the determination of the clock rate. Thus in the season 1906-07 the quantity r is almost wholly accounted for.

The p. e. just found is not to be looked upon as a new source of uncertainty in the observed time of vibration, for it enters into μ_0 and has therefore been already taken into account.

Having now arrived at values for the various errors I shall build up the probable error of the difference between the times of vibration at the Base and at a field station. This total p. e. I shall call E, taking as my unit the seventh decimal place of a second.

The p. e. represented by μ_0 appertains to the time of vibration of the mean pendulum derived from one set of observations: if there were during any season on an average n sets at each station, then the quantity to be used for that season, which I shall call μ_s, is

$$\sqrt{\frac{\mu_0}{n}}$$

In the early part of 1904 there were as a rule 4 sets of observations at each station; the value of μ_0 was $\pm 4{\cdot}7$.

Hence $\mu_s = \pm 2{\cdot}4$

The time of vibration at a field station is therefore burdened with the following errors :—

1.	μ_s	$\pm 2{\cdot}4$
2.	In the flexure correction ...	$\pm 1{\cdot}0$
3.	In the thermometer readings ...	$\pm 1{\cdot}0$
4.	In the temperature constant ...	$\pm 1{\cdot}0$
5.	In the density constant ...	$\pm 0{\cdot}8$
	Sum of squares	$\pm 9{\cdot}4$
	Total p. e.	$\pm 3{\cdot}1$

The time of vibration at Dehra Dún, with which comparison has to be made, is the mean of two separate series of observations and we have accordingly

6.	μ_s	$\pm 1{\cdot}7$
7.	Flexure	$\pm 0{\cdot}7$
8.	Change in the pendulums ...	$\pm 3{\cdot}0$
	Sum of squares	$12{\cdot}4$
	Total p. e.	$\pm 3{\cdot}5$

(Errors 3, 4 and 5 above are functions of the differences in temperature and density and have not to be applied a second time).

$$\text{Hence} \quad E = \sqrt{9{\cdot}4 + 12{\cdot}4} = \pm 4{\cdot}7$$

For the other seasons the figures are the same with the exception of μ_s which has the following values :—

For 1904-05 $\mu_s = \pm \frac{5 \cdot 7}{\sqrt{3}} = \pm 3 \cdot 3$ at a field station

$\mu_s = \pm 2 \cdot 4$ at Dehra Dún

For 1905-06 $\mu_s = \pm \frac{4 \cdot 0}{\sqrt{3}} = \pm 2 \cdot 4$ at a field station

$\mu_s = \pm 1 \cdot 7$ at Dehra Dún

For 1906-07 $\mu_s = \pm \frac{2 \cdot 1}{\sqrt{3}} = \pm 1 \cdot 2$ at a field station

$\mu_s = \pm 0 \cdot 9$ at Dehra Dún

Hence for the season 1904-05 $E = \sqrt{14 \cdot 5 + 22 \cdot 3} = \pm 6 \cdot 1$

For 1905-06 $E = \sqrt{9 \cdot 4 + 12 \cdot 4} = \pm 4 \cdot 7$

For 1906-07 $E = \sqrt{5 \cdot 1 + 10 \cdot 3} = \pm 3 \cdot 9$

These values of E are given in terms of the seventh decimal place as unit.

Having now evaluated the average probable errors of the differences in the times of vibration at the Base and at a field station for each season, it remains to show the corresponding probable errors of the deduced values of g.

The equation whence g at a field station is deduced is

$$s^2 g = s_0^2 g_0 = k$$

whence

$$g = \frac{k}{s^2}$$

$$dg = -\frac{2k\,ds}{s^3}$$

For the evaluation of $\frac{2k}{s^3}$ we may put

$$s_0 = s = 0 \cdot 507$$

and

$$g_0 = 979$$

Hence

$$\frac{2k}{s^3} = \frac{2 \times 979}{0 \cdot 507}$$
$$= 3862$$

Hence

$$\text{if } ds = 1 \times 10^{-7}$$

$$dg = 0 \cdot 000386$$

For the season ending in June 1904, $E = \pm 4 \cdot 7 \times 10^{-7}$
Therefore p.e. of $g = \pm 0 \cdot 0018$

For the season 1904-05 $E = \pm 6 \cdot 1 \times 10^{-7}$
Hence p.e. of $g = \pm 0 \cdot 0024$

For the season 1905-06 $E = \pm 4 \cdot 7 \times 10^{-7}$
Hence p.e. of $g = \pm 0 \cdot 0018$

For the season 1906-07 $E = \pm 3 \cdot 9 \times 10^{-7}$

Hence p.e. of $g = \pm 0 \cdot 0015$

These are the probable errors based on the observed value of g at Dehra Dún, *viz.*, 979·063; they do not include the error with which that value may be burdened.

CHAPTER VII.

In the tables in which the results of each season's work are summarised the last column contains the value of the quantity ($g_0'' - \gamma_0$.)

This quantity is the difference between the observed value of the force of gravity and that which theory would lead us to expect. In computing the corrections required for the reduction to sea level the density of the earth's crust, including all rock above sea level, has been assumed to be 2·8 and the mean density of the earth to be 5·6. If at any station ($g_0'' - \gamma_0$) is a positive quantity it shows that the density of the strata underlying that station is greater than 2·8, and if it is negative that the density is less.

What the actual densities are we cannot say unless we know the depths to which the excesses or defects extend but we can indicate the total amount of matter of density 2·8 which must be added to, or subtracted from, that which is visible in order to produce the observed deviation from the normal.

The attraction of a circular disc on a point in its axis, situated at a height c above its upper surface, the radius of the disc being r, and its thickness h is

$$K\left\{h + \sqrt{r^2 + c^2} - \sqrt{r^2 + (c + h)^2}\right\}$$

If r be very large compared with c and h this becomes Kh, that is to say the attraction depends on the thickness of the disc only, and is independent of the height of the station above it.

The value of K, when h is expressed in feet and the attraction in centimetres per second, and the density of the disc is taken to be half the mean density of the earth, is 0·000035.

Thus if we have to account for a deficiency in gravity of 0·001 c.m. we may say that there is a deficiency in the matter underlying the station equivalent to a disc of indefinitely great radius the thickness of which is

$$0{\cdot}001 \div 0{\cdot}000035 \quad \text{or} \quad 28{\cdot}6 \text{ feet.}$$

In this way we can compute the amount of the excess or defect of matter underlying each station, obtaining the thickness of what has been called by Professor Helmert "Die Ideelle Störende Schicht". Adding or subtracting this thickness to or from the known height of the station we obtain an ideal height which would be that of the station if the strata underlying it were expanded or compressed, as the case may be, until they attained a density of 2·8.

This is only approximately true for the corrections to the observed g on account of the masses between the station and sea level, $\left(g\,\frac{3}{4}\,\frac{h}{R}\right)$ and O have been computed on the assumption of a density of 2·8, whereas the very facts that we are dealing with show that this was not the actual density. Furthermore, when we have several stations in a small area and we find that the deficiencies to be accounted for differ by considerable amounts, the method of explaining the deficiencies by imagining each station to have under it a disc of indefinite extension and of a thickness proportional to the value of $(g_0'' - \gamma_0)$, breaks down, for we should have parts of two or more discs of different thicknesses under each station.

Nevertheless, since the central portion of the underlying disc is of much greater importance than the outer parts, the ideal heights give some idea of what would be the state of things if the crust were homogeneous and I have therefore drawn up a table to exhibit the actual heights, the thickness of the disturbing discs, and the ideal heights. In this table the stations have been grouped in regions.

Actual and Ideal Heights of Stations.

Station	Actual Height *feet*	$g_0'' - \gamma_0$ c.m.	Thickness of disturbing disc *feet*	Ideal Height *feet*
Dehra Dun and Great Arc.				
Mussooree (Dunseverick) ...	7129	− 0·115	− 3289	+ 3840
„ (Camel's Back) ...	6924	− 0·110	− 3143	+ 3781
Rájpur ...	3321	− 0·124	− 3546	− 225
Ḳálsi ...	1684	− 0·098	− 2800	− 1116
Dehra Dún ...	2239	− 0·126	− 3600	− 1361
Fatehpur ...	1434	− 0·100	− 2857	− 1423
Asarori ...	2467	− 0·112	− 3203	− 736
Hardwár ...	949	− 0·114	− 3260	− 2311
Mohan ...	1660	− 0·104	− 2974	− 1314
Roorkee ...	867	− 0·107	− 3060	− 2193
Nojli ...	879	− 0·095	− 2717	− 1838
Kuliána ...	810	− 0·058	− 1659	− 849
Meerut ...	734	− 0·027	− 772	− 38
Gesupur ...	691	− 0·020	− 572	+ 119
N. E. Longitudinal Series.				
Sandakphu ...	11766	− 0·150	− 4286	+ 7480
Darjeeling ...	6966	− 0·143	− 4090	+ 2876
Kurseong ...	4913	− 0·130	− 3718	+ 1195
Siliguri ...	387	− 0·137	− 3914	− 3527
Jalpaiguri ...	268	− 0·096	− 2746	− 2478
Calcutta Meridional Series.				
Kesarbari ...	204	− 0·043	− 1230	− 1026
Ramchandpur ...	132	+ 0·001	+ 29	+ 161
Kisnapur ...	113	+ 0·033	+ 944	+ 1057
Chatra ...	64	+ 0·009	+ 257	+ 321

Actual and Ideal Heights of Stations—(Continued).

Station	Actual Height *feet*	$g_0''-\gamma_0$ c.m.	Thickness of disturbing disc *feet*	Ideal Height *feet*
Other Himalayan and Sub-Himalayan Stations.				
Simla ...	7043	− 0·119	− 3403	+ 3640
Kálka ...	2202	− 0·085	− 2431	− 229
Pathánkot ...	1088	− 0·179	− 5114	− 4026
Plains of the Punjab.				
Ludhiána ...	835	− 0·048	− 1373	− 538
Mián Mir ...	708	+ 0·004	+ 114	+ 822
Ferozepore ...	647	+ 0·006	+ 172	+ 819
Montgomery ...	557	+ 0·003	+ 86	+ 643
Multán ...	404	− 0·045	− 1287	− 883
Dera Ghási Khan ...	397	− 0·088	− 2517	− 2120
Baluchistan and Sind.				
Quetta ...	5520	− 0·139	− 3971	+ 1549
Mach ...	3522	− 0·117	− 3346	+ 176
Sibi ...	434	− 0·116	− 3318	− 2884
Jacobabad ...	183	+ 0·031	+ 887	+ 1070
Coast Stations.				
Madras ...	20	+ 0·014	+ 400	+ 420
Colaba ...	34	+ 0·088	+ 2514	+ 2548
Cuttack ...	92	+ 0·029	+ 829	+ 921

Plates IV, V, VI and VII have been drawn to show graphically the difference between the visible section of the earth's surface and the ideal section.

The upper diagram in each plate shows the actual or visible section, that is to say the ordinates represent the actual heights of the stations above sea level. The middle diagram shows the thickness of the disturbing disc, and the third shows the ideal section, that is to say, the ordinates in it are the sums of the corresponding ordinates of the other two.

Owing to the lengths of the sections represented being widely different, it has not been possible to draw them all on the same scale, but the proportion between the horizontal and vertical scales in Plates IV, V and VI is the same, the vertical scale being about 40 times as large as the horizontal*. Plate VII covers a much less horizontal distance and in it the exaggeration of the vertical is not so great, being only about 10 to 1.

* These diagrams were originally drawn on the scale 30 miles to 1 inch horizontal and 4000 feet to 1 inch vertical, and they were afterwards reduced by photography to fit the page.

In these diagrams the first point to be noticed is that in and near the foot-hills there is always a great deficiency in the force of gravity, the disturbing disc is always thick; but it is also to be remarked that under hills its thickness in no case equals the height of the hill and it does not increase with the height of the hill. Thus in Plate IV the defect is almost constant from Siliguri to Sandakphu, in Plate VI from Sibi to Quetta and in Plate VII from Asarori to Mussooree.

This constancy in the defect leads to the result that in the ideal section there is a deep dip at the foot of hills and this dip has an important bearing on the deflections of the plumb-line.

In Plate IV a dotted line has been drawn on the diagram of the ideal section to show the way in which the deflection of the plumb-line in the meridian varies.

Judging by the visible section it seems impossible to believe that at Ramchandpur and Kesarbari the plumb-line is deflected to the south; but if to account for this observed fact we assume that the visible mass of the Himalayas is wholly compensated by deficiencies of density, we are equally at a loss to account for the appearance of a northerly deflection at Jalpaiguri which rises with great rapidity to a maximum at Kurseong.

The great dip between Kesarbari and Kurseong explains the observed effects quite satisfactorily. At Kesarbari there is nearly a balance between the attraction of the mass to the south aided by the dip to the north, and that of the far greater, but more distant Himalayas to the north. At Jalpaiguri part of the dip is already to the south tending to counteract the effect of the remainder that still lies to the north, the Himalayas are more powerful than the mass to the south and the plumb-line is therefore deflected in their direction.

At Kurseong the dip and the Himalayas acting in harmony produce the largest deflection that has yet been observed in India.

On receding from the hills in a direction more or less at right angles to them the force of gravity approaches the normal value and finally exceeds it, as at Kisnapur in Plate IV, Mián Mir and Montgomery in Plate V and Jacobabad in Plate VI.

The observations detailed in Chapter V were not carried sufficiently far south to ascertain whether this rule holds good in that region also, but it is probable that it does, for, as the first part of the table shows, the deficiency in g_0'' was growing steadily less, and at Gesupur was only about a fifth part of what it was at Nojli.

The investigation of the position of the locus of maximum values of $(g_0''-\gamma_0)$ is an important part of future pendulum operations.

Plate VIII shows the position of the stations near the Siwáliks and Himalayas the observations at which were given in Chapter V. The results are shewn in the first part of the table and in Plate VII. The noteworthy point is here the fact that the defects do not seem to be affected by the presence of the Siwálik range. There is for instance, no additional defect at Mohan or Hardwár. The difference from the normal seems to diminish with perfect regularity from Dehra Dún to Gesupur.

Throughout this area similarly placed stations have similar defects, though at western stations they are generally greater than at eastern ones.

Thus	at Kálsi the defect is	0·098	at Rájpur	0·124
	at Fatehpur	0·100	at Dehra Dún	0·126
	at Mohan	0·104	at Hardwár	0·114
	at Nojli	0·095	at Roorkee	0·107

These variations are however probably local.

INDEX OF THE PENDULUM STATIONS IN INDIA.

INDEX OF THE PENDULUM STATIONS IN INDIA—(*Continued*).

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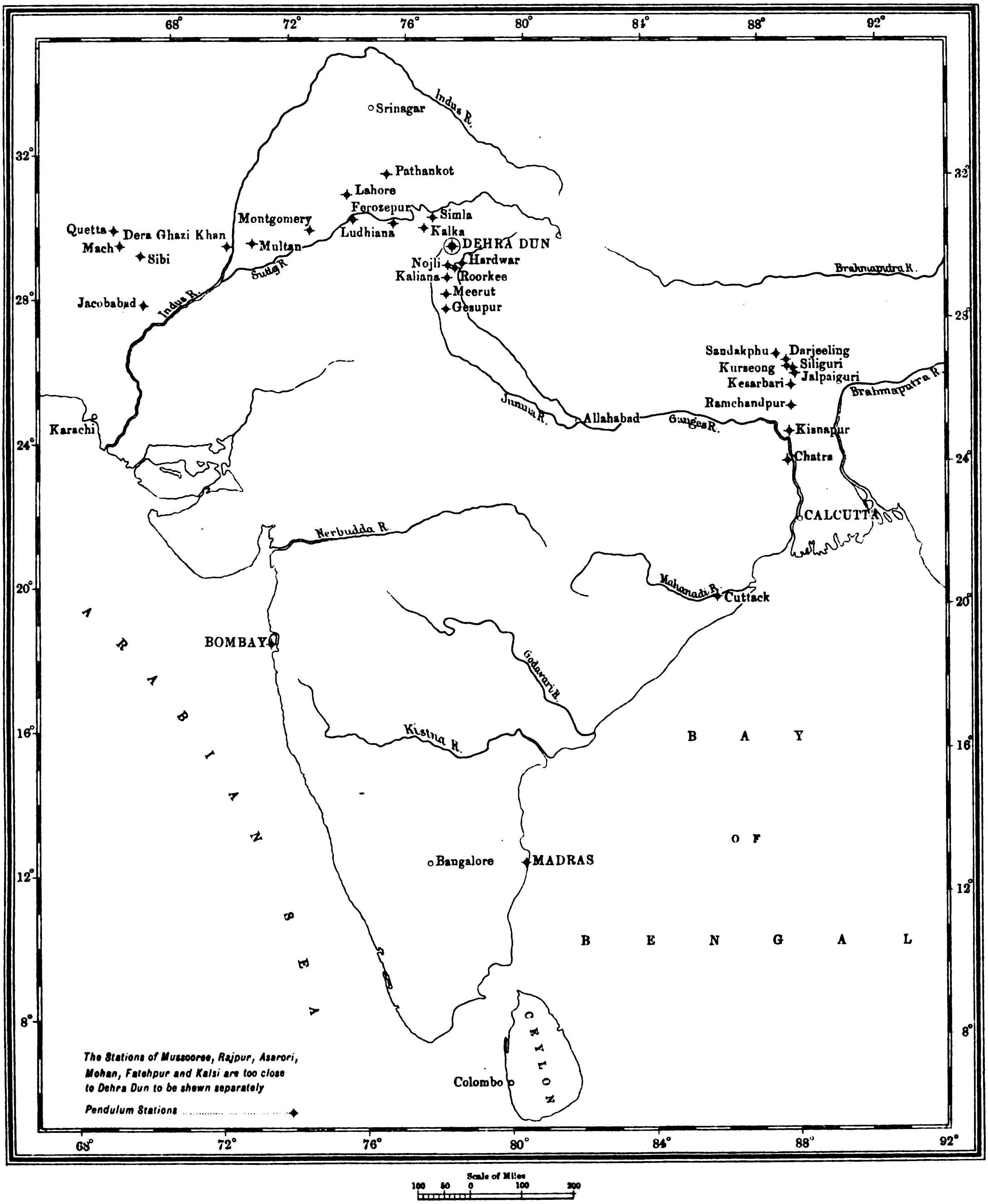
INDEX OF THE PENDULUM STATIONS IN INDIA—(*Continued*).

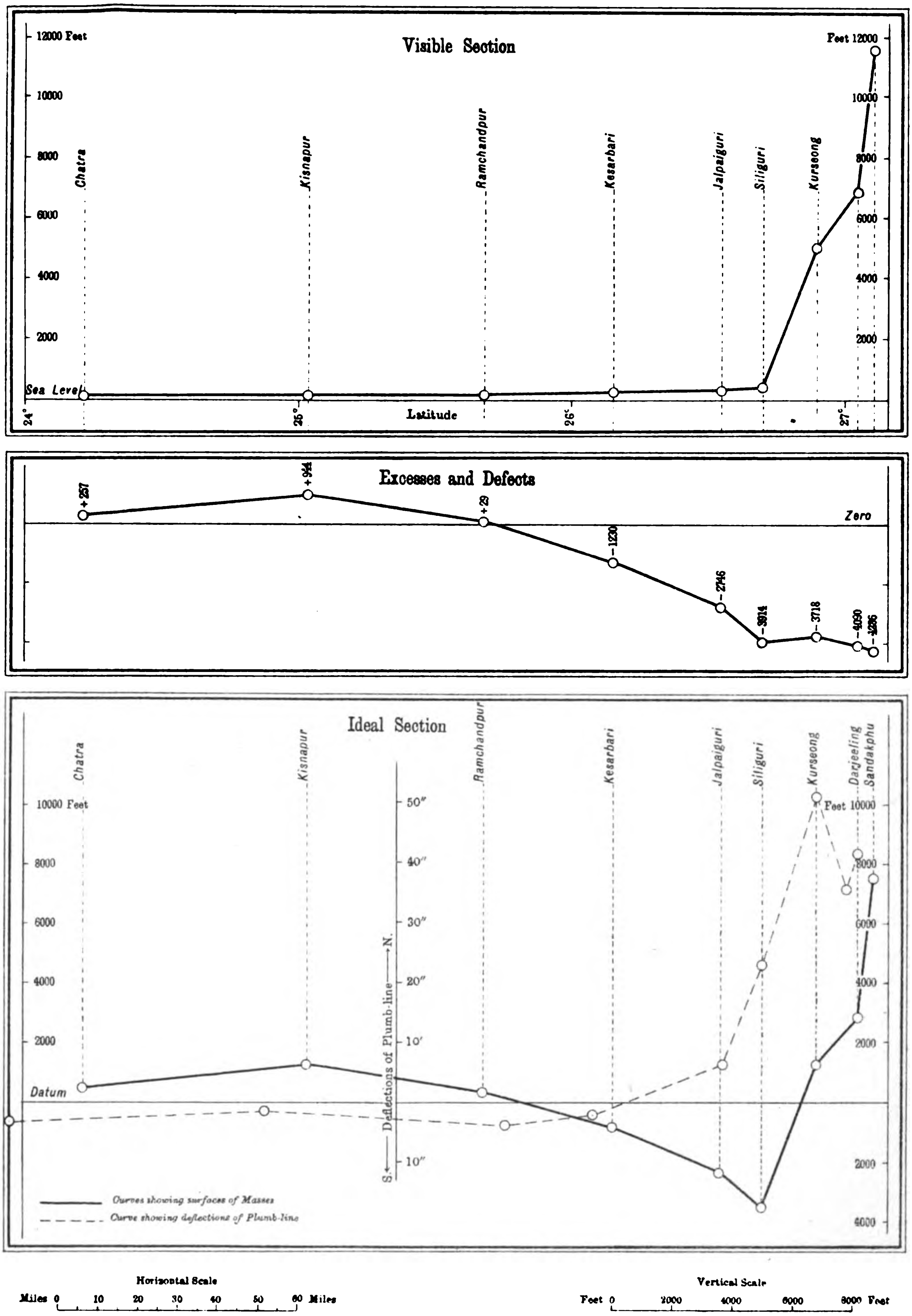
The table showing the real and ideal heights of all the stations is to be found on pp. 188, 189.

MAP Showing the PENDULUM STATIONS Seasons 1904 to 1907

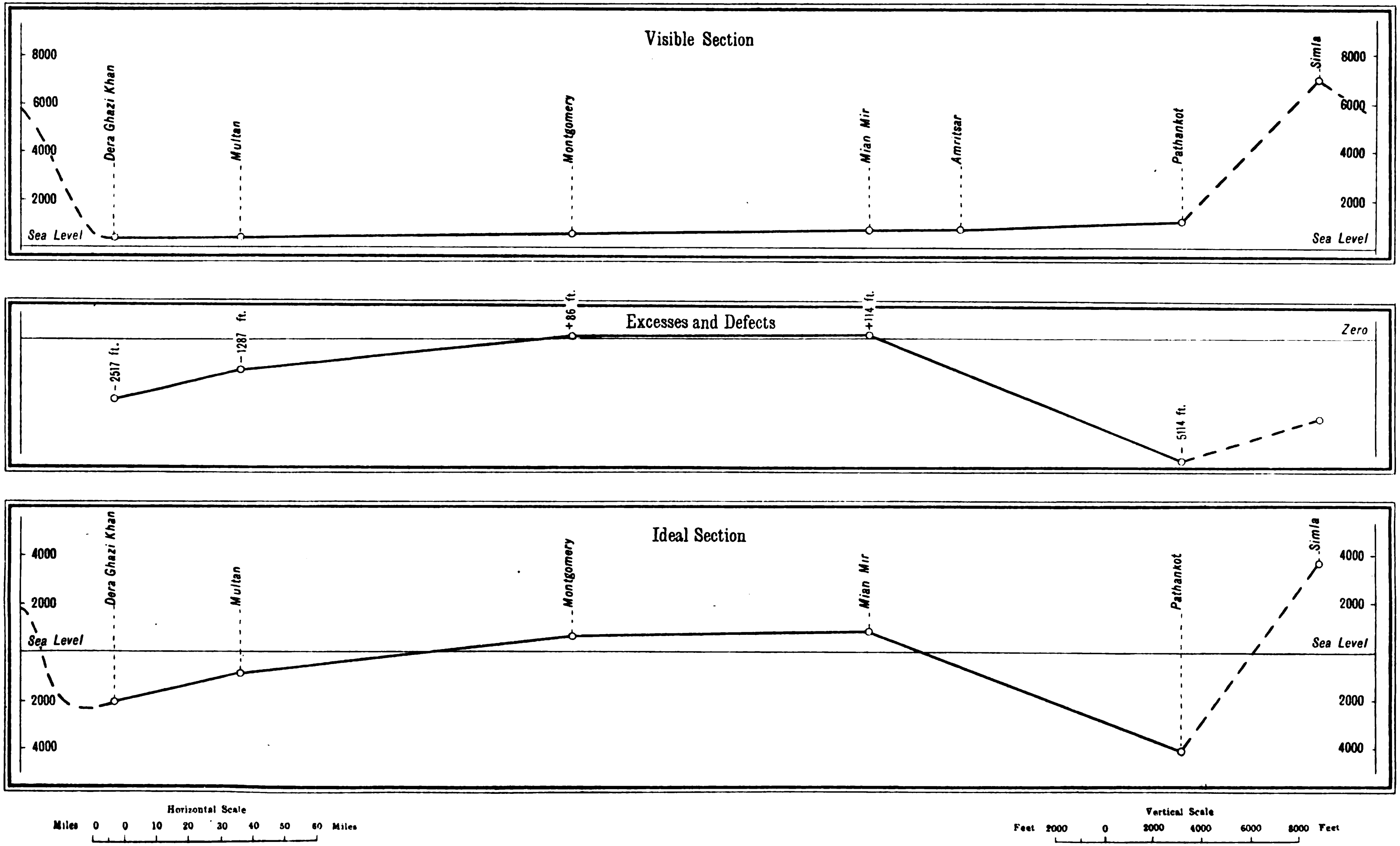
PLATE III



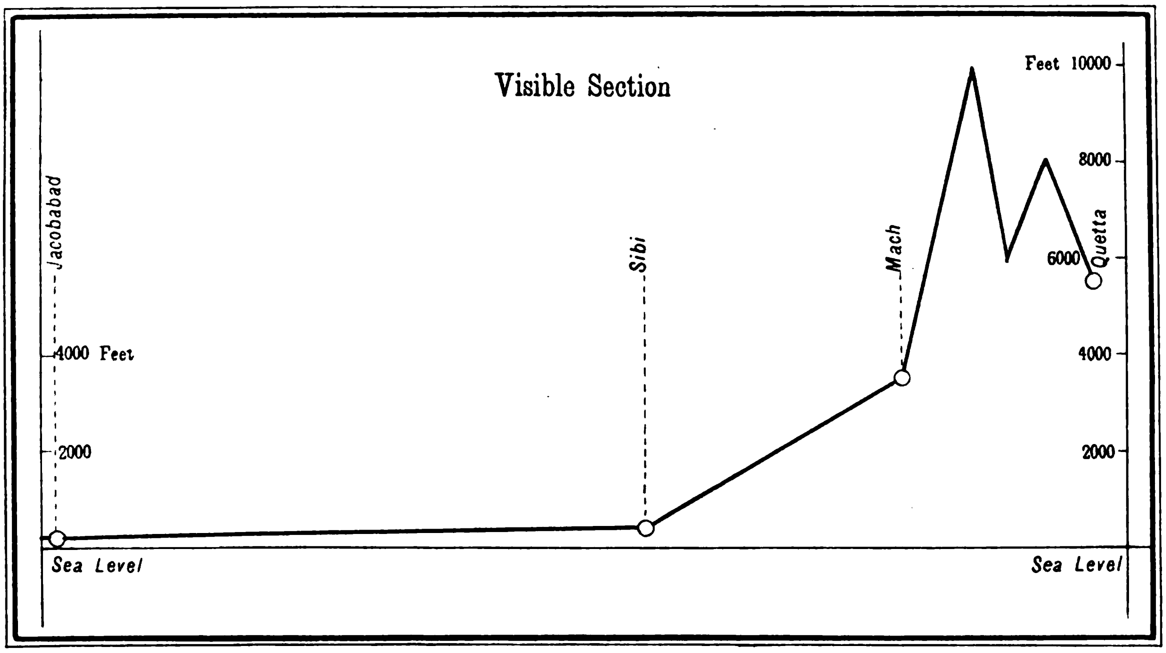
SECTION
from
CHATRA to SANDAKPHU

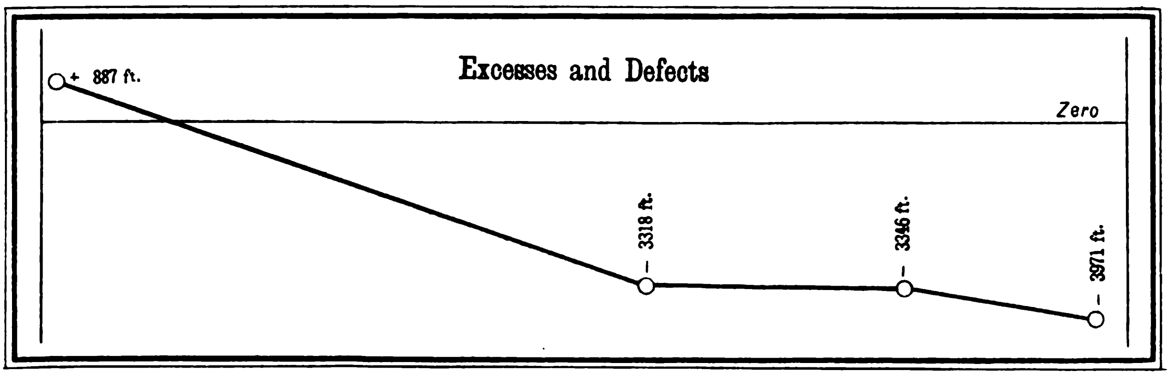


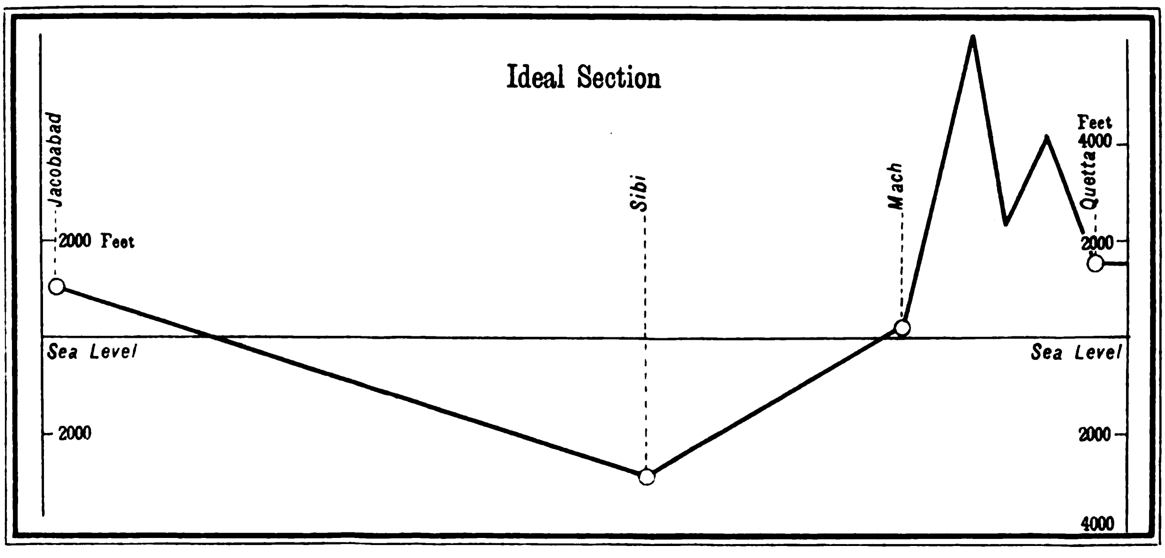
SECTION
from
THE SULEMAN MOUNTAINS
to
THE HIMALAYA



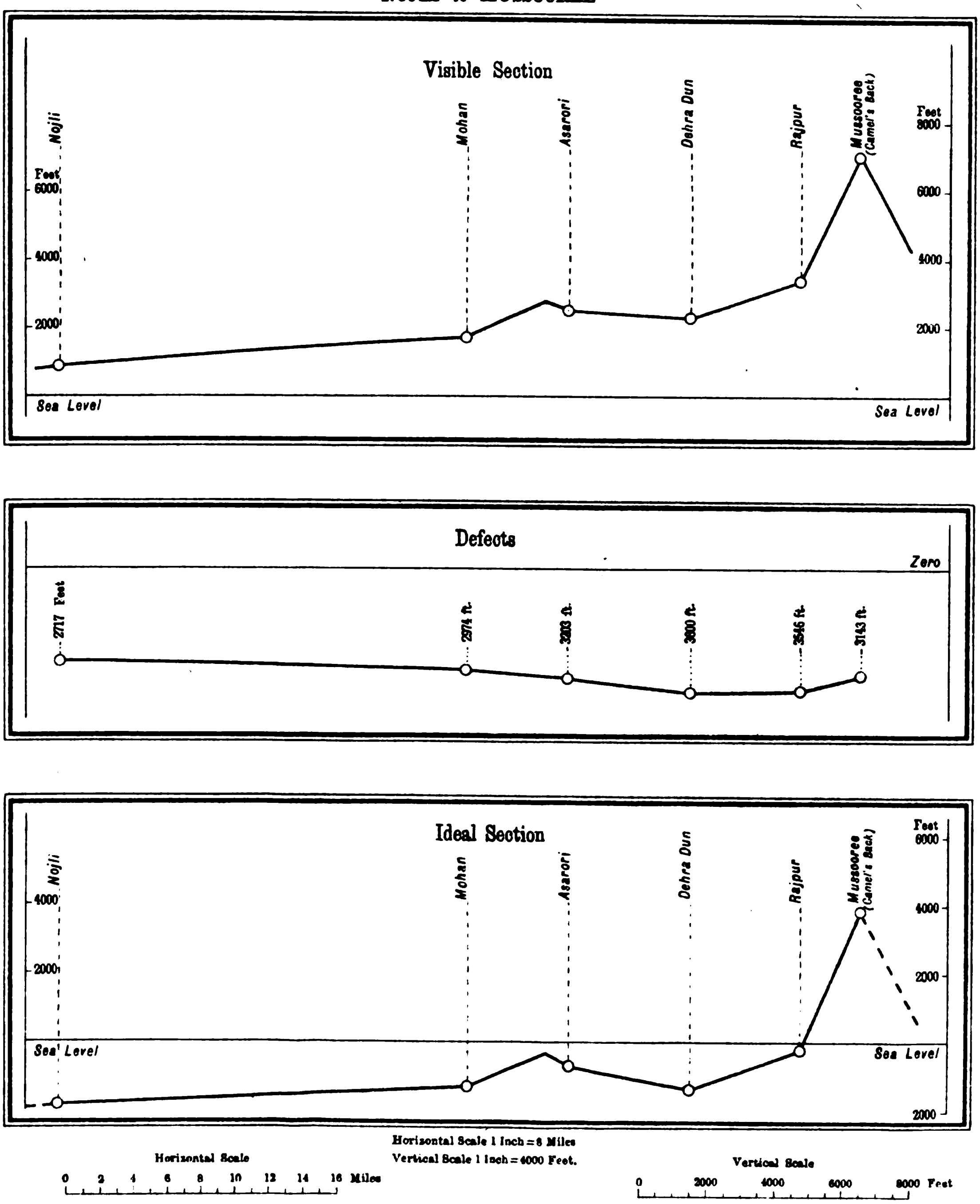
SECTION from JACOBABAD TO QUETTA







LARGE SCALE SECTION from NOJLI to MUSSOOREE



Map showing the PENDULUM STATIONS in the vicinity of Dehra Dun. PLATE VIII