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Some Problems on Time Change of Gravity

Part 3. On Precise Observation of the Tidal Variation of Gravity at the Gravity Reference Station

Part 4. On Continuous and Precise Gravity Observation during the Period of Annular Eclipse on April 19, 1958

and

Part 5. On Free Oscillations of the Earth Observed at the Time of the Chilean Earthquake on May 22, 1960

By

Ichiro NAKAGAWA

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Part 3. On Precise Observation of the Tidal Variation of Gravity at the Gravity Reference Station

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Abstract

It is an interesting and speculative problem whether the value of tidal factor of gravity might change with time or not. Really the value of the tidal factor of gravity obtained by one month's observation at any place on the earth is considerably diverse according to time of the observation. But it cannot simply be attributed to time change because the value of the tidal factor of gravity obtained by observation is regarded disturbed to some extent by shortness of the observation period, influence of the meteorological changes on the ground and instrument, and other unknown causes.

For the purpose of obtaining an accurate value of the tidal factor of gravity and solving the problem of time change of its value, it is necessary to determine the amount of effects caused by various disturbances upon the value of the tidal factor of gravity. From this line of thought, a precise and continuous observation of the tidal variation of gravity has been carried out at the Gravity Reference Station in Kyoto by means of the Askania gravimeter No. 111 since July 1959.

In the present article, results of harmonic analyses based on the data obtained by that observation during the first one year from August 1959 to August 1960 and the influence of the meteorological changes, are in detail described and it is ascertained that there is a diversity by only 3% in tidal factor of gravity during a year, so far as M_2-constituent is concerned, if the disturbing effects are excluded from the obtained results.

1. Introduction

The author (1) carried out 34 days' observation of the tidal variation of gravity at each of eleven stations in Japan by means of an Askania gravimeter No. 111 during a period of about two years from July 1957 to May 1959 (International Geophysical Year) — hereinafter referred to as 'one month's observation' in the present article — and discussed in detail various factors presumably affecting upon the tidal variation of gravity based on the data obtained by the aforementioned observations. As for M_2-constituent, it was concluded that the most reliable value of the tidal factor of gravity in Japan, free from influence of the oceanic tides, was 1.14, and that the phase lag between the observed and theoretical tides was very small even if it existed.

That discussion is based on the observational data extending over a month at each station. As the value of the tidal factor of gravity is closely correlated with the rigidity and density distributions of the whole earth, it is expected to show the same value wherever or whenever the observation be carried out. Nevertheless reports of many researchers show there are great diversities in the values of both the tidal factor of gravity and phase lag obtained actually at many stations in the world, and a considerable divergency far in excess of the observational error, has often been observed even at one station.

One month's observations, which were previously made at eleven stations, aimed mainly at investigating the influence upon the tidal variation of gravity caused by difference of various conditions of the observation station, but the time of observation at each station was different from one another. Therefore, the influences caused by difference in both observation station and epoch were by necessity to be included in the results obtained at each station. Then, a continuous observation for a period longer than one year at one station was necessitated so as partly to investigate the reliability of results obtained from the data extending over a month and to push a further detailed discussion on the occasion of the previous one month's observations, and partly to examine whether there existed really time change in the tidal factor of gravity and phase lag and to find clues for change if any in property of matters in the earth's interior.

Observational data of one month or shorter periods were used in almost all cases in order to investigate the tidal variation of gravity till some years ago. Because it was certainly no easy task to make a gravimetric observation of the tidal variation for a continuous period longer than one month from the viewpoint of labour in observation, since it was carried out by visual reading of the observers. By completion of a highly sensitive gravimeter with automatic recording apparatus, however, the accuracy of observation was largely increased and the length of observation periods was remarkably increased. Needless to say that the longer an observation was made, the higher reliability of results was obtained.

What were regarded to have an exceedingly important effect upon the tidal variation of gravity, were principally the oceanic tides and the geological structure around the station, as already described in the previous article (1) of the present study, but the meteorological disturbances were also regarded as one of unnegligible factors. The author tried to exclude an influence caused by the meteorological disturbances from the observed tidal variation of gravity on the occasion of the previous one month's observations. In that case, since various conditions were almost different at each station, it was exceedingly troublesome to tell apart precisely the disturbance effects. Furthermore, an observation period extending over a month was regarded too short to discuss the influence caused by the meteorological and other disturbances. Therefore, a detailed discussion re above was not dared. But, when an observation was continuously made at one station, the position of the observation station, effect caused by the oceanic tides, influence of the local geological structure around the station and others became common and consequently a consideration for these points was not necessitated. Such being the case, only time change including the apparent change of gravity caused by the meteorological disturbances could in detail be examined.

Under such circumstances, a long period observation of the tidal variation of gravity with the Askania gravimeter No. 111, commenced in July 1959 at Kyoto, has been continued to the present. In the following, a study concerning the various points mentioned above is described, based on the data obtained by the observation during a period of the first one year from August 1959 to August 1960 — hereinafter referred to as 'one year's observation' in the present article, — and accurate values of the tidal factor of gravity and phase lag at Kyoto free from influence of the meteorological disturbances, are obtained.

On the other hand, in practical observation, if it was made at one station and during the same period, there would crop up a problem whether the same observational results could be obtained or not irrespective of the instrument used. In order to investigate this problem, it was desirable to carry out a simultaneous observation setting side by side more than two sets of gravimeters in the same room. The first observation to fulfil such a purpose was made at the Kanozan Geodetic Observatory by means of two Askania gravimeters, No. 105 and No. 111, in 1958. The results obtained by both gravimeters showed a fairly good agreement, as already described in the previous article (1) of the present study, so far as M_2-constituent was concerned. But a detailed comparison for them was not made owing to two facts — that the period of the simultaneous observation was only 34 days and that variations of room temperature and atmospheric pressure were considerably violent. Fortunately, a highly precise simultaneous observation of the tidal variation of gravity was carried out at Kyoto by means of two Askania gravimeters of No. 105 and No. 111 during a period of one year's observation. By comparing and scrutinizing the results obtained by this observation, it naturally became clear that to what extent the results obtained by one gravimeter alone could be reliable, and also found a clue to elucidate the original nature of micro-change of gravity, sometimes observed simultaneously and commonly at two stations in far distance, as already indicated (2).

2. Observations

An Askania Gs-11 gravimeter No. 111 with automatic recording apparatus was used in the present observation. Observation was carried out at Kyoto continuously during a period of about one year from August 1959 to August 1960. Though it was temporarily interrupted in order to observe the tidal variation of gravity at Wakayama during a period of about two months from September to November 1960, it was resumed to the present time.

The observation station was situated in an underground special room of the Geophysical Institute of Kyoto University where the International Reference Station of Gravity in Japan. Temperature and humidity in this room were maintained at 19.5°C±0.2°C and 55%±1% respectively throughout a year by means of a thermostatically controlling apparatus. But sudden changes of room temperature sometimes took place owing to failure of the electric power supply, that of the water supply and bad condition of the thermostatically controlling apparatus. In such cases, it was immediately restored back to the normal state, but their effects were presumed to be fairly large. The gravimeter and recorder were installed on a concrete block isolated from the building.

Details concerning the observation station are shown in Table 3.1.

Table 3.1. Description of the observation station

Observation station	:	Kyoto
Latitude	:	35° 01.8′ N
Longitude		135° 47.2′ E
Height		59.9 metres above mean sea level
Depth	:	2.4 metres below ground surface
Observation room	:	International Reference Station of Gravity in Japan (Geophysical Institute of Kyoto University)

Needless to mention that all electric currents were stabilized with high accuracy and circuits were in good connection with the earth. Thermostat of the gravimeter was set up at 40°C. The rotation speed of the recording paper was 8 mm/hour and it was renewed once a day. Time-marks were recorded at every hour on the recording paper and their accuracy was ±30 seconds. Calibrations of the instrument and observations of the time change of gravity were carried out by the same method as at the previous one month's observations (**1**, **3**) except that the period of the present observation was longer.

During a period of one year's observation at Kyoto, an Askania Gs-11 gravimeter No. 105 belonging to the Geographical Survey Institute was set up side by side in the same room, and a simultaneous observation with two Askania gravimeters was continuously carried out during a period of about seven months from January to August 1960. Both gravimeters were installed in the distance of two metres in the same room. For the purpose of comparing and scrutinizing the observational results obtained by both gravimeters and also for investigating the micro-change of gravity, it was extremely inconvenient to use electricity in measuring system of the gravimeter. To speak the truth, the micro-change of gravity, even if it was recorded on the registrogram, could not be distinguished from an apparent change caused by fluctuation of the electric power. As for the Askania gravimeter No. 111, electric power to supply the main lamp which illuminated a photocell was doubly stabilized, while for the Askania gravimeter No. 105, a well-aging battery was used for that electric power. The data obtained by the latter gravimeter are now in the process of analysis, and the registrograms obtained by both gravimeters are compared with each other and scrutinized so as to detect micro-change in gravity. Under these circumstances, results obtained by the Askania gravimeter No. 105 and a discussion concerning the micro-change of gravity, are not described in the present article, but the observational results of the tidal variation of gravity obtained with the Askania gravimeter No. 111, are in detail described.

3. Calibrations of the instrument

In the present one year's observation, calibrations of the gravimeter and recorder were carried out thoroughly in the same method as in the previous one month's observations (**1**, **4**). Especially, in the present observation, they could be made at beginning and end of the observation independently, and consequently they were made quite thoroughly. During the observation periods, the only calibration of sensitivity of the recording was made by means of resetting the gravimeter spindle. The observation was operated by setting the instruments in the best condition.

Before and after the observation of the tidal variation of gravity, the value of the spindle scale corresponding to displacement of the calibration ball, was determined by use of a built-in bead device and it was shown in Table 3.2.

Table 3.2. Values of spindle scale corresponding to ball displacement

	Date	Position of scale (scale div.)	Spindle displacement (scale div.)
At the start of observation	July 29, 1959	41.62	5.5149
At the end of observation	Aug. 18, 1960	42.39	5.5125
Mean	Feb. 8, 1960	42.005	5.5137±0.0012

As the ball value is 41.554 mgal at the observation station (**1**), the spindle scale constant of the gravimeter can easily be calculated. It is shown in Table 3.3 with that given by the maker for the same position of spindle.

As could easily be seen from Table 3.3, the spindle scale constant of the

Table 3.3. Spindle scale constant determined by the method of bead displacement

Thermostat setting : 40°C

	Position of scale (scale div.)	Spindle scale constant (mgal/div.)	Maker's value* (mgal/div.)	Difference (%)
At the start of observation	41.62	7.5349	7.5346	0.004
At the end of observation	42.39	7.5381	7.5349	0.042
Mean	42.005	7.5365±0.0017	7.5347	0.024

* The value given by the maker for the same position of spindle.

Askania gravimeter No. 111, determined by the bead displacement method, was in good agreement with that given by the maker within 0.04%. From the calibrations made in the previous one month's observations, the author (**1**, **4**) had reached to a conclusion that a difference between both values was within 0.1% so far as temperature in the thermostat of the gravimeter was

Table 3.4. Scale coefficient of recording

Analysis number	Number of shift	Scale coefficient of recording (mm/0.01 div.)	Error (%)
1	5	29.147 ± 0.199	± 0.68
2	3	29.887 ± 0.298	± 1.00
3	4	30.307 ± 0.209	± 0.69
4	4	30.658 ± 0.196	± 0.64
5	4	29.956 ± 0.294	± 0.98
6	7	29.022 ± 0.328	± 1.13
7	4	29.287 ± 0.573	± 1.96
8	4	29.004 ± 0.456	± 1.57
9	2	29.098 ± 0.473	± 1.63
10	4	28.915 ± 0.222	± 0.77
11	4	29.512 ± 0.171	± 0.58
12	4	29.536 ± 0.196	± 0.66
13	4	29.511 ± 0.218	± 0.74
14	5	29.557 ± 0.127	± 0.43
15	3	28.658 ± 0.688	± 2.40
16	4	28.636 ± 0.479	± 1.67
17	2	28.519 ± 0.157	± 0.55
One year	49	29.363 ± 0.113	± 0.38

maintained at 40°C. The result in the present calibration was of the same order as the previous. Therefore, the value of scale constant of the gravimeter given by the maker was solely used in the succeeding treatment of the observational data.

The calibration of recording was concentrically carried out at the beginning and end of the observation as in the previous one month's observations, and during the observation it was timely made by means of resetting the gravimeter spindle. Value of the scale coefficient of recording for each analytical period obtained by method of extrapolation is shown in Table 3.4. In this table, a value obtained by assuming that no change in sensitivity of the recording was found throughout the whole observational periods, was shown.

From the Table 3.4, it was clear that the maximum change of the scale coefficient of recording reached 7% during a year. The recorded curve of the gravity change was fluctuated since June 1960 in comparison with that of the previous periods. Since then, there were clear differences in both the value of the scale coefficient of recording and its mean error. It was assumed that the voltage stabilizer connected with circuit of the main lamp that illuminated the photocell, had become irregular because of a continuous use of it for a few years. It was therefore concluded that a change of the scale coefficient of recording, was within 5% during the first year and that accuracy to determine the scale coefficient of recording at each analytical period, was about 1% except for special cases.

Table 3.5 showed a scale constant of the gravimeter for the mean position of the spindle scale which was made in the gravimetric tidal observation in each analytical period. The values shown in this table were obtained from a sensitivity table (**5**) given by the maker.

The value of scale constant of the recording for each analytical period deduced from the values given in Tables 3.4 and 3.5, is shown in Table 3.6. In further treatment of the observational data, the scale constant of recording shown in Table 3.6 is used.

Change of the scale constant of recording in a continuous observation with an Askania gravimeter was recently reported by P. Melchior (**6**, **7**) and N. N. Pariisky (**8**). According to Melchior's reports, there was change of 10~20% during the observation period of one year, while according to Pariisky, it was 5~7% during four months. The Pariisky's result was almost similar to the author's, but the Melchior's was slightly larger. Fur-

Table 3.5. Spindle scale constant

Analysis number	Position of scale* (scale div.)	Spindle scale constant** (mgal/div.)
1	38.938	7.5336
2	39.009	7.5336
3	39.049	7.5336
4	39.081	7.5336
5	39.123	7.5337
6	39.156	7.5337
7	39.196	7.5337
8	39.229	7.5337
9	39.257	7.5337
10	39.312	7.5337
11	39.357	7.5337
12	39.399	7.5338
13	39.434	7.5338
14	39.468	7.5338
15	39.518	7.5338
16	39.559	7.5339
17	39.589	7.5339
One year	39.260	7.5337

* Mean position of spindle scale in observation.

** Spindle scale constant given by the maker.

Table 3.6. Scale constant of recording

Analysis number	Scale constant of recording (μgal/mm)	Error (%)
1	2.5847±0.0177	±0.68
2	2.5207±0.0252	±1.00
3	2.4858±0.0172	±0.69
4	2.4573±0.0158	±0.64
5	2.5149±0.0248	±0.99
6	2.5959±0.0294	±1.13
7	2.5724±0.0504	±1.96
8	2.5975±0.0409	±1.57
9	2.5891±0.0422	±1.63
10	2.6055±0.0201	±0.77
11	2.5528±0.0149	±0.58
12	2.5507±0.0170	±0.67
13	2.5529±0.0189	±0.74
14	2.5489±0.0110	±0.43
15	2.6289±0.0632	±2.40
16	2.6309±0.0441	±1.68
17	2.6417±0.0146	±0.55
One year	2.5657±0.0099	±0.38

thermore, L. Steinmetz (**9**) pointed out that sensitivity of a North American gravimeter No. 167 was a function of temperature, but no remarkable relation was found between both values of the sensitivity and temperature in case of the Askania gravimeter No. 111 used in the present observation.

4. Observational results

The observational data were treated by the same method as in the previous one month's observations (**1**). The data used for analysis were hourly read values as collectively shown in the tables at the end of the present article. The drift curve of gravimeter was, first of all, eliminated from all the hourly read values by Pertzev's method (**10**). The drift curve of the Askania gravimeter No. 111 thus obtained is shown in Fig. 3.1 with graphs of atmos-

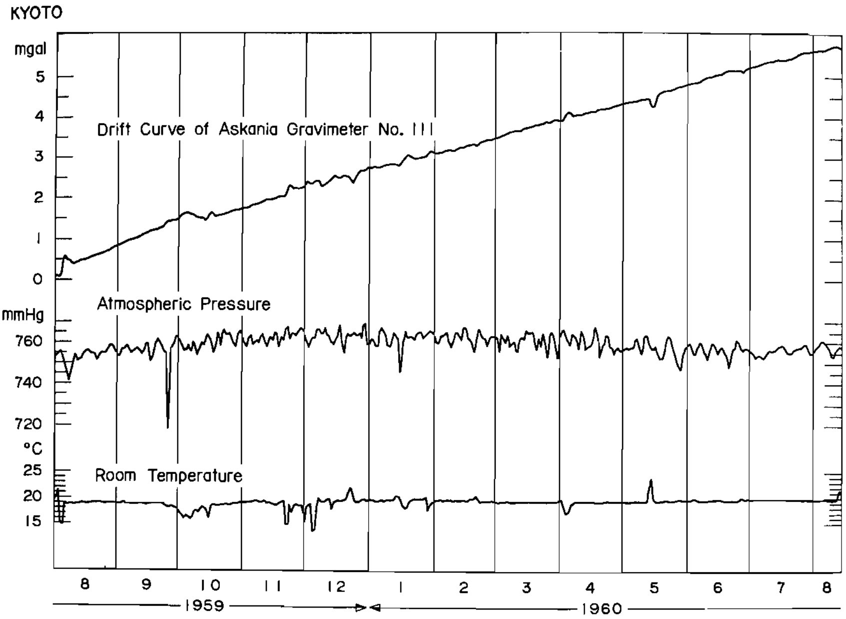

Fig. 3.1. Drift curve of the Askania gravimeter No. 111 determined by Pertzev's method and the changes of atmospheric pressure and room temperature.

Table 3.7. Average values of drift speed determined by Pertzev's method

Time	Drift speed (μgal/day)
August 1959	+ 17.3
September 1959	+ 21.3
October 1959	+ 8.0
November 1959	+ 18.3
December 1959	+ 14.9
January 1960	+ 11.7
February 1960	+ 12.3
March 1960	+ 14.4
April 1960	+ 13.4
May 1960	+ 15.5
June 1960	+ 13.9
July 1960	+ 14.2
August 1960	+ 8.9
One year	+ 14.4

Table 3.8. Central epoch adopted for harmonic analysis

Analysis number	Central epoch (UT)
1	Aug. 24, 00h, 1959
2	Sept. 14, 00h, 1959
3	Oct. 5, 00h, 1959
4	Oct. 26, 00h, 1959
5	Nov. 16, 00h, 1959
6	Dec. 7, 00h, 1959
7	Dec. 28, 00h, 1959
8	Jan. 18, 00h, 1960
9	Feb. 8, 00h, 1960
10	Feb. 29, 00h, 1960
11	Mar. 21, 00h, 1960
12	Apr. 11, 00h, 1960
13	May 2, 00h, 1960
14	May 23, 00h, 1960
15	June 13, 00h, 1960
16	July 4, 00h, 1960
17	July 25, 00h, 1960

Table 3.9. Values

Analysis number	M_2		S_2		N_2	
	R (μgal)	ε (degree)	R (μgal)	ε (degree)	R (μgal)	ε (degree)
1	60.402±0.161	330.78±0.17	27.180±0.163	0.03±0.30	8.248±0.168	187.73±1.17
2	58.860±0.177	176.80±0.17	31.164±0.180	96.08±0.35	8.726±0.184	123.52±1.27
3	58.506±0.155	21.67±0.17	31.957±0.157	104.70±0.29	8.901±0.161	26.38±1.05
4	60.398±0.109	131.72±0.10	28.258±0.110	115.32±0.24	11.722±0.113	332.10±0.57
5	58.601±0.130	80.17±0.15	24.370±0.131	115.27±0.32	12.360±0.135	265.22±0.74
6	60.801±0.096	288.82±0.10	22.619±0.098	111.15±0.25	12.022±0.100	205.57±0.49
7	59.537±0.088	137.35±0.10	20.182±0.089	95.05±0.27	13.825±0.092	147.47±0.39
8	60.620±0.152	345.58±0.15	22.962±0.154	82.23±0.42	12.136±0.158	84.15±0.85
9	59.306±0.124	193.57±0.14	28.176±0.126	81.05±0.29	10.096±0.129	18.58±0.74
10	59.526±0.084	41.25±0.09	30.202±0.085	90.60±0.24	8.891±0.087	309.38±0.57
11	60.512±0.078	249.68±0.09	30.875±0.079	88.57±0.17	8.937±0.081	234.80±0.54
12	61.797±0.089	98.48±0.09	29.301±0.090	97.28±0.19	7.973±0.092	154.50±0.67
13	59.419±0.106	306.05±0.12	25.523±0.107	99.23±0.27	11.451±0.110	97.57±0.60
14	60.240±0.078	153.45±0.09	22.350±0.079	98.53±0.22	12.835±0.081	34.13±0.37
15	56.750±0.111	0.95±0.14	21.652±0.113	98.57±0.32	12.413±0.116	332.08±0.54
16	58.816±0.111	207.42±0.12	19.881±0.112	95.27±0.35	13.396±0.115	259.73±0.52
17	59.688±0.097	54.92±0.10	18.333±0.098	89.12±0.49	11.443±0.101	190.00±0.52

of R_{obs} and ε_{obs}

K_1		O_1		Q_1	
R (μgal)	ε (degree)	R (μgal)	ε (degree)	R (μgal)	ε (degree)
34.311±0.178	182.37±0.32	24.439±0.174	311.40±0.42	5.893±0.174	118.47±1.82
36.042±0.196	216.40±0.32	33.132±0.191	143.83±0.35	6.308±0.191	46.12±1.80
33.758±0.172	250.62±0.30	28.343±0.168	201.47±0.35	2.576±0.168	318.67±3.94
39.536±0.120	279.92±0.20	27.335±0.118	156.15±0.25	4.362±0.118	274.32±2.44
50.214±0.143	296.08±0.17	22.946±0.140	338.33±0.35	4.236±0.140	185.30±1.92
59.216±0.106	306.48±0.12	32.332±0.104	165.20±0.21	6.939±0.104	97.88±0.97
64.551±0.097	311.88±0.09	28.208±0.095	0.07±0.19	7.475±0.095	354.57±0.74
61.079±0.168	321.05±0.17	29.806±0.164	184.35±0.32	8.278±0.164	260.68±1.30
45.077±0.137	332.97±0.19	27.851±0.134	16.62±0.29	6.689±0.134	200.92±1.15
35.787±0.093	352.10±0.15	26.072±0.091	200.87±0.22	4.095±0.091	117.67±1.34
26.083±0.086	31.18±0.19	27.487±0.084	30.72±0.19	4.080±0.084	356.05±1.19
24.936±0.098	79.27±0.24	27.587±0.096	206.90±0.22	3.552±0.096	264.87±2.22
37.064±0.117	107.48±0.19	29.511±0.114	43.30±0.24	6.890±0.114	216.63±0.97
44.817±0.086	119.73±0.12	29.653±0.084	237.95±0.17	6.725±0.084	117.17±0.75
48.796±0.123	129.93±0.17	28.692±0.120	56.77±0.25	6.210±0.120	28.10±1.14
51.474±0.122	141.75±0.14	29.446±0.119	246.07±0.24	4.682±0.119	297.97±1.54
47.860±0.107	153.27±0.14	26.831±0.104	75.10±0.24	8.513±0.104	192.95±0.72

Table 3.10. Values of R_{theor} and ε_{theor}

Analysis number	M_2		S_2		N_2		K_1		O_1		Q_1	
	R (μgal)	ε (degree)	R (μgal)	ε (degree)	R (μgal)	ε (degree)	R (μgal)	ε (degree)	R (μgal)	ε (degree)	R (μgal)	ε (degree)
1	52.802	331.85	25.405	355.00	7.976	180.43	31.562	183.59	24.032	311.18	3.773	155.22
2	52.006	178.92	27.463	91.92	7.749	105.85	24.064	207.80	23.215	141.89	4.288	66.06
3	52.099	26.88	27.690	99.12	9.107	33.47	24.674	251.67	22.864	216.80	4.628	343.25
4	52.550	234.73	26.084	104.60	10.476	332.02	33.114	282.13	24.428	155.24	4.585	280.67
5	51.558	83.54	23.270	105.52	10.700	269.67	42.278	299.08	22.351	340.25	4.503	191.90
6	52.252	290.52	20.765	100.00	11.034	206.71	48.796	309.44	25.115	168.36	4.967	100.12
7	51.914	139.50	20.274	90.34	10.947	147.78	50.234	317.81	23.118	0.20	5.466	357.85
8	52.395	347.57	22.344	81.37	9.773	87.13	46.393	326.83	24.200	184.40	5.169	253.39
9	51.792	195.18	25.325	79.17	8.653	18.44	38.294	339.44	24.115	16.37	4.465	204.94
10	52.697	43.59	27.738	97.96	7.970	309.71	28.475	357.72	22.666	200.53	3.419	116.48
11	52.067	251.25	28.372	87.74	7.449	235.25	23.004	42.26	24.406	28.83	3.029	352.63
12	52.485	99.31	27.012	94.15	8.120	160.64	27.826	82.51	22.411	215.68	4.196	269.85
13	51.934	306.84	24.029	98.84	9.174	94.04	36.645	105.70	24.524	40.89	5.010	188.30
14	52.372	155.16	20.650	99.66	10.171	28.90	43.809	119.55	23.470	232.33	5.109	108.48
15	51.950	2.56	18.229	94.74	11.049	327.44	47.608	129.83	24.118	55.61	4.964	27.87
16	52.059	211.24	18.096	93.47	11.017	267.65	47.352	159.33	24.596	249.02	4.689	302.46
17	52.039	58.12	20.370	81.84	10.380	205.93	43.063	150.01	23.263	73.53	4.805	216.41

Table 3.11. Values of G and κ

Harmonic analysis : Lecolazet's method

Analysis number	Central epoch (UT)	M_2		S_2		N_2		K_1		O_1		Q_1	
		G	κ	G	κ	G	κ	G	κ	G	κ	G	κ
1	Aug. 24, 00h, 1959	1.144±0.004	−1°.07±0°.18	1.070±0.007	+ 5°.03±0°.31	1.034±0.022	+ 7°.30±1°.18	1.087±0.006	− 1°.22±0°.33	1.017±0.008	+ 0°.22±0°.43	1.562±0.047	−36°.75±1°.83
2	Sept. 14, 00h, 1959	1.132±0.004	−2.12±0.18	1.135±0.007	+ 4.16±0.36	1.126±0.024	+17.67±1.28	1.498±0.009	+ 8.60±0.33	1.427±0.009	+ 1.94±0.36	1.471±0.045	−19.94±1.81
3	Oct. 5, 00h, 1959	1.123±0.003	−5.21±0.18	1.154±0.006	+ 5.58±0.29	0.977±0.019	− 7.09±1.06	1.368±0.008	− 1.05±0.31	1.240±0.008	−15.33±0.36	*0.557±0.037	−24.58±3.94
4	Oct. 26, 00h, 1959	1.149±0.003	−3.01±0.11	1.083±0.005	+10.72±0.24	1.119±0.011	+ 0.08±0.58	1.194±0.004	− 2.21±0.21	1.119±0.005	+ 0.91±0.26	0.951±0.026	− 6.35±2.44
5	Nov. 16, 00h, 1959	1.137±0.003	−3.37±0.16	1.047±0.006	+ 9.75±0.33	1.155±0.013	− 4.45±0.74	1.188±0.004	− 3.00±0.18	1.027±0.007	− 1.92±0.36	0.941±0.032	− 6.60±1.93
6	Dec. 7, 00h, 1959	1.164±0.003	−1.70±0.11	1.089±0.005	+11.15±0.26	1.090±0.010	− 1.14±0.49	1.214±0.003	− 2.96±0.13	1.287±0.005	− 3.16±0.21	1.397±0.021	− 2.24±0.98
7	Dec. 28, 00h, 1959	1.147±0.002	−2.15±0.11	0.995±0.005	+ 4.71±0.28	1.263±0.009	− 0.31±0.39	1.285±0.002	− 5.93±0.09	1.220±0.005	− 0.13±0.19	1.368±0.018	− 3.28±0.74
8	Jan. 18, 00h, 1960	1.157±0.003	−1.99±0.16	1.028±0.007	+ 0.86±0.43	1.242±0.017	− 2.98±0.86	1.317±0.005	− 5.78±0.18	1.232±0.008	− 0.05±0.33	1.601±0.033	+ 7.29±1.31
9	Feb. 8, 00h, 1960	1.145±0.003	−1.61±0.14	1.113±0.006	+ 1.88±0.29	1.167±0.016	+ 0.14±0.74	1.177±0.004	− 6.47±0.19	1.155±0.006	+ 0.25±0.29	1.498±0.030	− 4.02±1.16
10	Feb. 29, 00h, 1960	1.130±0.002	−2.34±0.09	1.089±0.004	− 7.36±0.24	1.116±0.012	− 0.33±0.58	1.257±0.004	− 5.62±0.16	1.150±0.005	+ 0.34±0.23	1.198±0.027	+ 1.19±1.34
11	Mar. 21, 00h, 1960	1.162±0.002	−1.57±0.09	1.088±0.003	+ 0.83±0.18	1.200±0.012	− 0.45±0.54	1.134±0.004	−11.08±0.19	1.126±0.004	+ 1.89±0.19	1.347±0.028	+ 3.42±1.19
12	Apr. 11, 00h, 1960	1.177±0.003	−0.83±0.09	1.085±0.004	+ 3.13±0.19	0.982±0.012	− 6.14±0.68	0.896±0.004	− 3.24±0.24	1.231±0.005	− 8.78±0.23	0.847±0.024	− 4.98±2.23
13	May 2, 00h, 1960	1.144±0.003	−0.79±0.13	1.062±0.005	+ 0.39±0.28	1.248±0.013	+ 3.53±0.61	1.011±0.004	+ 1.78±0.19	1.203±0.005	+ 2.41±0.24	1.375±0.023	+28.33±0.98
14	May 23, 00h, 1960	1.150±0.002	−1.71±0.09	1.082±0.005	− 1.13±0.23	1.262±0.008	+ 5.23±0.38	1.023±0.002	+ 0.18+0.13	1.263±0.004	+ 5.62±0.18	1.316±0.017	+ 8.69±0.76
15	June 13, 00h, 1960	1.092±0.003	−1.61±0.14	1.188±0.007	+ 3.83±0.33	1.123±0.011	+ 4.64±0.54	1.025±0.003	+ 0.10±0.18	1.190±0.006	+ 1.16±0.26	1.251±0.025	+ 0.23±1.14
16	July 4, 00h, 1960	1.130±0.003	−3.82±0.13	1.099±0.007	+ 1.80±0.36	1.216±0.011	− 7.92±0.53	1.087±0.003	+ 2.42±0.14	1.197±0.006	− 2.95±0.24	0.999±0.026	− 4.49±1.54
17	July 25, 00h, 1960	1.147±0.002	−3.20±0.11	0.900±0.005	+ 7.28±0.49	1.102±0.011	−15.93±0.53	1.111±0.003	+ 3.26±0.14	1.153±0.005	+ 1.57±0.24	*1.772±0.022	−23.46±0.73

pheric pressure and room temperature in the corresponding period. A clear correlation is not found between the drift curve of gravimeter and pressure variation, but there exists a fairly good correlation between the drift curve and temperature variation. Monthly and wholly average values of the drift speed determined by Pertzev's method are shown in Table 3.7.

After elimination of the drift, the hourly values were immediately harmoniously analysed by Lecolazet's method (**11**) to obtain harmonic constants. The author (**12**) had already compared and scrutinized the methodical superiority or inferiority for two methods of harmonic analysis, Lecolazet's and Doodson-Lennon's, based on the same observational data. From that study, it was concluded that Lecolazet's method was methodically superior though the results obtained by two methods were practically equal so far as M_2-constituent was concerned. Therefore, Lecolazet's method was used for harmonic analysis in the present investigation.

When the observational data extending over a year such as the present case, are harmoniously analysed by Lecolazet's method, they must suitably be divided into several parts, because it can be applied originally to only the data of one month. As for the epoch of analysis in such a case, R. Lecolazet (**13**) proposed it to be every 21 days. Therefore, 17 analyses are made in the present one year's observation. Central epochs of harmonic analysis adopted are shown in Table 3.8.

Ten tidal constituents of M_2, S_2, N_2, L_2, $2N_2$, K_1, O_1, Q_1, J_1 and M_1 were obtained by the harmonic analysis. But in the present article, only the analytical results for six principal tidal constituents — M_2 (principal lunar semi-diurnal constituent), S_2 (principal solar semi-diurnal constituent), N_2 (larger lunar elliptic semi-diurnal constituent), K_1 (luni-solar declinational diurnal constituent), O_1 (lunar declinational diurnal constituent) and Q_1 (lunar elliptic diurnal constituent) — were described, the other constituents were not because their amplitudes were too small to be expected of deducing any significant results.

In Table 3.9 are shown the observed amplitude R_{obs} and phase ε_{obs} of each constituent for each epoch of the analysis obtained by Lecolazet's method. The results of harmonic analysis can be expressed in the form $R_{obs}\cos(nt+\varepsilon_{obs})$ for each constituent. The mean errors of R_{obs} and ε_{obs} shown in this table are values obtained by using error combination introduced by R. Lecolazet (**14**).

Table 3.12. Values of pseudoharmonic terms of room temperature and atmospheric pressure

Room temperature

Analysis number	M_2		S_2		N_2		K_1		O_1		Q_1	
	R (0.01°C)	ε (degree)	R (0.01°C)	ε (degree)	R (0.01°C)	ε (degree)	R (0.01°C)	ε (degree)	R (0.01°C)	ε (degree)	R (0.01°C)	ε (degree)
1	1.150	271.88	0.802	124.28	1.381	175.60	0.088	37.13	1.529	339.60	2.683	211.25
2	0.753	75.22	0.551	106.00	0.375	202.05	0.449	118.90	1.883	115.63	0.860	331.92
3	3.241	257.35	3.144	136.02	1.078	268.08	14.272	186.47	1.241	273.18	5.644	346.30
4	1.347	119.82	0.935	152.97	0.778	7.83	2.570	199.05	4.382	324.27	2.841	259.68
5	7.158	84.95	1.910	61.97	4.000	254.15	6.552	51.78	2.481	156.38	4.592	280.53
6	10.063	177.55	14.228	189.43	12.002	163.62	12.222	39.33	4.646	52.93	6.131	27.82
7	1.024	221.15	1.692	172.33	3.184	125.20	8.872	175.48	1.257	329.80	2.428	114.37
8	6.082	215.22	2.371	134.70	2.850	178.80	3.974	178.95	4.565	306.27	2.734	285.23
9	1.031	122.05	2.023	11.43	1.285	11.03	2.956	197.45	1.631	292.20	2.736	41.12
10	0.271	46.90	0.633	97.53	0.380	314.25	3.435	229.45	2.446	64.70	0.528	325.80
11	1.080	78.80	1.236	94.87	0.218	195.70	2.396	161.68	1.822	116.57	1.726	276.95
12	6.343	314.13	6.696	107.38	4.427	265.82	10.421	177.70	9.081	45.03	8.252	340.43
13	1.003	36.12	1.316	61.80	1.070	172.43	5.616	111.65	8.303	104.27	7.291	284.22
14	0.865	217.75	1.002	93.03	0.696	110.33	3.954	97.43	5.804	272.95	8.085	179.52
15	0.526	248.68	0.340	274.72	0.215	138.58	1.372	81.10	1.094	78.23	2.011	255.02
16	2.668	183.53	2.333	294.78	3.281	119.07	7.649	333.47	6.852	174.42	7.741	126.23
17	0.154	61.23	0.100	328.05	0.186	122.23	0.127	208.78	0.228	132.87	0.526	231.87

Atmospheric pressure

Analysis number	M_2		S_2		N_2		K_1		O_1		Q_1	
	R (0.01 mmHg)	ε (degree)	R (0.01 mmHg)	ε (degree)	R (0.01 mmHg)	ε (degree)	R (0.01 mmHg)	ε (degree)	R (0.01 mmHg)	ε (degree)	R (0.01 mmHg)	ε (degree)
1	0.759	107.95	37.061	337.38	6.756	168.03	50.781	71.50	8.909	302.08	18.658	202.87
2	23.935	194.25	41.149	311.50	22.497	354.83	83.434	44.37	57.627	323.15	53.157	139.22
3	31.775	33.07	46.798	319.20	19.686	290.90	80.800	47.47	74.949	175.97	61.572	74.70
4	2.055	34.82	46.867	359.48	5.212	204.78	39.393	67.62	11.123	88.43	19.891	321.50
5	15.976	219.28	51.337	351.73	8.319	124.13	23.331	66.23	9.369	342.92	6.037	28.08
6	22.465	97.97	45.426	346.47	20.569	36.67	27.984	89.95	5.908	140.55	14.120	359.07
7	6.675	275.28	52.706	358.70	0.981	20.97	65.301	78.90	2.180	2.00	8.533	35.35
8	5.287	156.08	45.168	356.80	1.714	56.78	53.184	75.52	34.140	313.12	24.093	357.53
9	1.355	66.83	43.482	334.07	5.215	194.23	31.634	54.82	14.623	177.05	2.859	233.78
10	11.863	226.33	55.962	338.00	13.093	177.30	27.002	35.08	13.523	139.35	7.115	144.43
11	6.857	29.17	40.775	340.73	9.377	340.77	39.795	81.42	24.985	349.85	16.257	56.02
12	8.929	297.40	44.506	337.43	5.543	239.47	62.254	72.28	40.997	345.70	13.017	82.35
13	21.271	221.10	61.678	342.23	19.223	109.17	58.867	55.60	42.611	191.75	46.643	39.92
14	5.773	309.78	39.844	332.18	9.615	5.28	37.710	68.60	12.518	86.05	10.830	27.70
15	2.443	55.57	36.167	330.20	3.444	274.37	46.570	64.87	12.117	294.48	12.496	6.60
16	6.664	340.57	34.338	326.85	2.105	107.70	45.107	60.45	5.069	156.47	1.683	13.37
17	3.977	190.02	40.387	334.77	1.482	22.92	64.406	64.72	7.813	268.82	9.397	237.15

On the other hand, the theoretical values for each constituent can theoretically be calculated by Lecolazet's method. The theoretical values of R_{theor} and ε_{theor} corresponding to R_{obs} and ε_{obs} are shown in Table 3.10.

Thus, the tidal factor of gravity G and phase lag κ are calculated by the formulae

$$G=\frac{R_{obs}}{R_{theor}} \quad \text{and} \quad \kappa=\varepsilon_{obs}-\varepsilon_{theor} \tag{3.1}$$

respectively. The obtained values of G and κ are shown in Table 3.11, where the positive sign of κ shows that the observed tide advances the theoretical one, while the negative sign shows the former lags behind the latter. Elimination of the drift curve and harmonic analysis are carried out by an electronic computing machine 'IBM-650' at the Centre International des Marées Terrestres in Bruxelles.

During the gravimetric tidal observation, changes of room temperature and atmospheric pressure were observed simultaneously. These data were read at every hour and analysed for the same epoch as the gravimetric tidal data. The results of analysis corresponding to Table 3.9, are shown in Table 3.12.

5. Discussion

Results of harmonic analysis are shown in Table 3.11 for six major tidal constituents. In spite of the continuous observation at one station, the values of G and κ for each constituent are largely diverse due to difference of the analysis period, as can easily be seen from Table 3.11. M_2-constituent is the most trustworthy among the constituents obtained from data extending over a month and its amplitude is the largest at a region of medium latitudes such as Japan. Even for such the M_2-constituent, there are differences by about 8% in tidal factor of gravity and by about 5° in phase lag during a year, and as for the other constituents, there are larger differences compared with the M_2-constituent. In the following, a detailed discussion concerning the cause of their diversity is described for the M_2-constituent alone.

(1) Comparison with long period observations made in foreign countries

A long period observation of the tidal variation of gravity has recently been carried out by many researchers at various stations in the world and its results are successively being reported. Some of the results obtained by such observations made during the last several years, are shown in Table 3.13.

R. Lecolazet (**16**) had observed the tidal variation of gravity by means of a North American gravimeter No. 138 at Strasbourg, and 43 analyses were made based on the data obtained in the period extending over two years by his own method. According to his results, there were differences by 5% in tidal factor of gravity and by 3° in phase lag, for M_2-constituent. P. Melchior (**6**) made continuously a gravimetric tidal observation with an Askania gravimeter No. 145 at Bruxelles since July 1958, having 43 analyses by Lecolazet's method and 44 analyses by Doodson-Lennon's respectively based on the data for about sixteen months, and he showed that there were differences by 8% in tidal factor of gravity and by 4° in phase lag for M_2-constituent except for special cases. A long period observation was also made by G. Jobert (**17**) with a LaCoste-Romberg gravimeter No. 5 at Paris and the observational data obtained were harmoniously analysed by Lecolazet's method. Concerning the M_2-constituent, the difference in his results was 2% in tidal factor of gravity and 3° in phase lag. On the other hand, N. N. Pariisky (**8**) reported collectively the observational results of earth tides made recently in USSR. In this report, he described the results of a simultaneous observation made over about four months with two Askania gravimeters, No. 126 and No. 134, at Tachkent. 9 analyses were made of the data observed by the former gravimeter and 10 for the latter, both of which were analysed by Pertzev's method of harmonic analysis. According to his report, there were differences of about 5% in tidal factor of gravity and about 2° in phase lag both in time and instrument for M_2-constituent. Besides the aboves similar long period observations were carried out by many researchers yielding results very similar to those mentioned above.

Although those results were obtained by using different instruments and by applying different analytical methods of the data, so far as M_2-constituent was concerned, differences of about 5% in tidal factor of gravity and of about 4° in phase lag were induced due to difference in epoch of the analysis, or in other words, time of the observation. This meant that a careful study was necessitated in case of making a detailed discussion based on analytical results obtained by one month's observation. Especially, the observation made by R. Lecolazet (**16**) at Strasbourg was different from the author's one in instrument, but the treatment of the data was quite the same — speaking in more detail, there was a difference by about 5 days in selection of the central

Table 3.13. Values of G and κ obtained

Station	Latitude (N)	Longitude (E)	Height (m)	Instrument*	Observation period
Gênes	44°24′	8°56′	54	A- 97	Oct. 1960—Mar. 1961
Strasbourg	48 35	7 47	138	N-138	Aug. 1957—Jan. 1960
Paris	48 50	2 20		R- 5	Sept. 1958—Feb. 1959
Uccle	50 48	4 21	101	A-145	July 1958—Dec. 1959
Borowiec	52 16	17 04		A-110	Feb. 1959—May 1959
Poulkovo	59 46	30 19	71	A-124, 135	Apr. 1958—Oct. 1958
Krasnaya P.	55 28	37 19	190	A-124, 126, 134, 135	Jan. 1958—Jan. 1959
Alma-Ata	43 11	76 58	1400	A-126, 134	Oct. 1958—May 1959
Tachkent				A-126, 134	Nov. 1959—Mar. 1960
Lantschou				A-124, 135	June 1959—Aug. 1959
Chiba	35 38	140 38	27	A-105	July 1957—Mar. 1958
Kanozan	35 15	139 58	351	A-105	Apr. 1958—Dec. 1958
Caracas	−10 30	293 05		A- 99	Mar. 1958—Nov. 1960

Station	G					
	M_2	S_2	N_2	K_1	O_1	Q_1
Gênes	1.196	1.203	1.224	1.141	1.150	1.317
Strasbourg	1.193	1.190	1.182	1.151	1.168	1.163
Paris	1.196	1.206	1.180	1.153	1.169	
Uccle	1.186	1.243	1.249	1.176	1.183	1.172
Borowiec	1.210	1.067	1.314	1.145	1.184	0.965
Poulkovo	1.238	1.217	1.222	1.194	1.180	
Krasnaya P.	1.191	1.182	1.143	1.156	1.160	
Alma-Ata	1.135	1.132	1.129	1.137	1.143	
Tachkent	1.137	1.126	1.131	1.122	1.148	
Lantschou	1.143	1.130	1.131	1.131	1.137	
Chiba	1.141	1.114	1.028	1.194	1.092	
Kanozan	1.449	1.171	1.654	1.321	1.174	
Caracas	1.174	1.230	1.128	1.336	1.139	1.667

* A . Askania N : North American R : LaCoste-Romberg

at various stations in the world

Number of day	Method of analysis**	Author
150	L	M. Bossolasco & G. Cicconi (15)
860	L	R. Lecolazet (16)
174	L	G. Jobert (17)
486	L	P. Melchior (6, 7)
91	L	J. Witkowski (18)
232	P	J. S. Dobrokhotov & others (19)
174	P	N. N. Pariisky & others (20)
232	P	N. N. Pariisky & others (8, 21, 22)
232	P	N. N. Pariisky (8, 22)
116	P	N. N. Pariisky (8, 22)
274	L	Geographical Survey Institute (23)
150	L	Geographical Survey Institute (23)
654	L	G. Fiedler & J. Pérez (24, 25)

κ					
M_2	S_2	N_2	K_1	O_1	Q_1
+ 0°.06	+ 0°.44	+ 0°.91	+ 1°.48	− 0°.36	+11°.08
+ 1.56	− 1.41	+ 2.33	− 0.25	− 0.77	− 1.19
+ 3.69	+ 3.08	+ 4.33	+ 1.20	+ 1.02	
+ 0.10	+ 0.60	− 1.52	+ 1.95	+ 0.43	+ 2.12
− 1.20	− 1.39	− 2.60	− 3.95	− 2.78	− 2.52
− 2.1	− 1.6	− 6.0	− 2.6	− 1.8	
− 4.6	− 2.8	− 6.1	− 2.0	− 0.7	
− 3.7	− 3.8	− 2.4	− 0.8	− 3.3	
− 4.3	− 4.3	− 5.2	− 1.6	− 1.2	
− 3.5	− 5.6	− 3.2	− 3.0	− 1.7	
+ 0.72	− 4.98	−12.28	− 2.67	+ 2.87	
+ 2.32	− 3.56	− 0.04	− 1.90	+10.38	
+ 0.18	− 0.64	+ 0.38	+ 2.71	+ 0.03	− 0.02

** L : Lecolazet P : Pertzev

epoch in analysis — and his conclusion obtained was quite similar to the author's. Above all, it was a noteworthy result that time changes of the tidal factor of gravity and phase lag for M_2-constituent obtained by the author during a period of about seven months from August 1959 to February 1960, were closely similar to those obtained by R. Lecolazet (**16**) in the same periods. A detailed discussion what this fact means is now in examining.

(2) Mean value of the results

There is a considerable difference in the obtained results, as already

Table 3.14. Mean values of G and κ for each constituent
Mean epoch : Feb. 8, 00h, 1960 (UT)
Period of analysis : Aug. 9, 1959—Aug. 8, 1960 (366 days)

	G	κ
M_2	1.143 ± 0.005	− 2°.24 ± 0°.29
S_2	1.077 ± 0.016	+ 3.68 ± 1.13
N_2	1.142 ± 0.023	− 0.48 ± 1.78
K_1	1.169 ± 0.037	− 1.90 ± 1.12
O_1	1.190 ± 0.024	− 0.94 ± 1.17
Q_1	1.275 ± 0.062	− 5.15 ± 3.62

Table 3.15. Mean values of G and κ for semi-diurnal and diurnal constituents
Mean epoch : Feb. 8, 00h, 1960 (UT)
Period of analysis : Aug. 9, 1959—Aug. 8, 1960 (366 days)

	Semi-diurnal constituents		Diurnal constituents	
	G	κ	G	κ
Mean with weights $p=R$	1.125±0.023	−0°.40±1°.83	1.184±0.038	−1°.78±1°.43
Mean with weights $p=\frac{1}{e^2}$	1.137±0.025	−1.84±2.33	1.193±0.036	−1.62±1.48

Table 3.16. Mean values of G and κ for all constituents
Mean epoch : Feb. 8, 00h, 1960 (UT)
Period of analysis : Aug. 9, 1959—Aug. 8, 1960 (366 days)

	All constituents	
	G	κ
Mean with weights $p=R$	1.150 ± 0.029	− 1°.00 ± 1°.19
Mean with weights $p=\frac{1}{e^2}$	1.140 ± 0.030	− 1.82 ± 1.22

pointed out, depending upon the difference of observation time. As to the cause of such diversity, it is suspected that the observational error, disturbance due to other phenomena and a real change of those results, are probably responsible. But taking an average of the analytical results during a year, results free from these effects must be obtained as a preliminary step. Mean values of G and κ for each constituent thus obtained are shown in Table 3.14. Values marked with asterisk in Table 3.11 are omitted in calculating the mean value because they seem to be abnormal. The mean square error shown in Table 3.14 is obtained according to agreement of the analytical results for the independent monthly series.

Mean values of G and κ for semi-diurnal and diurnal constituents are shown in Table 3.15 and those for all constituents in Table 3.16. As yet, the instrumental phase lag of an Askania gravimeter with a highly precise galvanometer has not been accounted for.

The value of the tidal factor of gravity was determined in theoretical investigations by H. Takeuchi, H. Jeffreys, C. L. Pekeris and others. H. Takeuchi (**26**) and H. Jeffreys (**27**) estimated Love's numbers, h and k, scrutinizing earth tides based on the equilibrium theory, while C. L. Pekeris and others (**28**) obtained them based on the dynamical theory. By using the Love's numbers obtained, they calculated the following values as the tidal factor of gravity.

Table 3.17. Theoretical values of G

	M_2	S_2	K_1	O_1
H. Jeffreys (**27**)	1.152		1.183	1.221
C. L. Pekeris, H. Jarosch & Z. Alterman (**28**)	1.150	1.162	1.16	1.18
H. Takeuchi (**26**)	1.185 - 1.210			

Concerning the M_2-constituent, as could easily be seen from Table 3.13, values of the tidal factor of gravity obtained at some stations in Southeastern Asia were about 1.14 commonly, while those in Europe at the same periods were larger than 1.19. The values in Southeastern Asia were much smaller than those derived by the theoretical investigations as shown in Table 3.17. According to the theoretical investigations, as could be seen from Table 3.17, the tidal factor of gravity for semi-diurnal constituents must be smaller than that for diurnal ones. The results obtained by the author proved it. An almost similar tendency was recognized in the observational results in Southeastern Asia. On the contrary, the tidal factor of gravity for semi-diurnal constituents was clearly larger than that for the diurnal in Europe. It was also recognized for all principal constituents that the observed tide lagged behind the theoretical one in Southeastern Asia, while the former advanced the latter in Europe. Thus, there was a distinct difference in results between Southeastern Asia and Europe. It seemed very interesting to examine in detail whether this difference was real one or apparent one due to meteorological disturbances, difference of the continental geological structure and effect by existence of the Pacific Ocean. The author is now investigating this problem in detail.

According to many observational results in foreign countries, the value of the tidal factor of gravity obtained at one station was found to be considerably diverse with time. It seemed that its diversity was too large to be explained solely as an observational error. For instance, P. Melchior (**29**) reported that a large anomaly of the value of $G(K_1)/G(O_1)$ was observed simultaneously at two stations, Bruxelles and Strasbourg, during July – August 1959. He (7) also observed simultaneously a large diversity of $G(M_2)$ with two Askania gravimeters at Bruxelles in May – July 1960. As for the former, it occured around the start of the present one year's observation and consequently the data worthy to investigate in detail this fact were not obtained yet. But, as for the latter, an applicable fact was also observed by the author at the same periods. Namely, the largest deviation of $G(M_2)$ in the present one year's observation made by the author was observed in May – July 1960 and it amounted to about 8% of the tidal factor of gravity (see Fig. 3.2). If it took place simultaneously at Bruxelles and Kyoto by the same cause, its cause was a phenomenon extended over a wide area all over the world. It was very interesting to investigate thoroughly the cause. It had came to a conclusion that the difference of tidal factor of gravity for M_2-constituent depending upon the difference of observation time was within 4% in the present investigation except for the periods of May – July 1960.

(3) Influence caused by meteorological changes

As to the cause affecting upon the tidal variation of gravity, various factors are suspected, as already mentioned above. But in a continuous observation at one place such as the present case, it is unnecessary to take into consideration the position of the observation station, effect caused by the oceanic tides, and difference of the local geological structure around the station. It is therefore regarded that the observational error, influence caused by meteorological changes, diversity depending upon difference of the observation time and others, are included in diversity of the observational results.

Then, in the following a trial to exclude the influence caused by meteorological changes from the observational results, is made first of all. In this section, the discussion is restricted to M_2-constituent alone. Influence upon the gravimeter caused by change of the meteorological factors is generally divided into two parts. Namely, one is a direct influence on measuring system of the gravimeter and the other an indirect influence on the gravimeter through change of the earth surface caused by the meteorological changes. Usually, the effect caused by the latter is exceedingly small, and consequently what is regarded to exercise an important effect upon the observational results, is practically that of the former. Therefore, it is natural to show different results in compliance with variety of the gravimeters used in observation. Change of temperature exerts an effect upon the observed values as a change in length of the gravimeter spring and that of atmospheric pressure as change of buoyancy acted on the gravimeter mass. In order to avoid these effects, in an Askania gravimeter, the gravimeter itself is enclosed in a thermostat with accuracy of 0.01°C, and equipped with floats (5). But their effects cannot perfectly be excluded.

Now, let one adopt the following notation.

$R\cos(\omega t+\varepsilon)$: the M_2-component of the observed gravimetric tides at any epoch in μgals,

$R_1\cos(\omega t+\varepsilon_1)$: the M_2-component of the theoretical gravimetric tides at the same epoch in μgals,

$R_T\cos(\omega t+\varepsilon_T)$: the observed room temperature component with speed of M_2-period in degrees C, and

$R_P\cos(\omega t+\varepsilon_P)$: the observed atmospheric pressure component with speed of M_2-period in mmHg.

A relation between these values is given by the following expression,

$$d\cdot R\cos(\omega t+\varepsilon)=G'\cdot R_1\cos(\omega t+\varepsilon_1)+\gamma\cdot R_T\cos(\omega t+\varepsilon_T)+\delta\cdot R_P\cos(\omega t+\varepsilon_P), \tag{3.2}$$

where d, γ and δ are the correction factors for drift-elimination, temperature and pressure variations respectively, and G' the most probable tidal factor of gravity through the one year's observation free from the influence of temperature and pressure variations. Among these factors, the value of d is fixed depending on the method used for drift-elimination (**12**, **30**), and its value is 0.99934 in the present case. The values of G', γ and δ can be obtained by method of the least square using the values given in Tables 3.9, 3.10 and 3.12. Their values thus obtained are shown in Table 3.18.

Table 3.18. Values of G', γ and δ

$G'=1.138\pm0.005$

$\gamma=-17\pm8$ μgal/°C

$\delta=-3.9\pm1.7$ μgal/mmHg

Since influence of the oceanic tides is negligibly small at Kyoto, as already shown in the previous article (**1**) of the present study, the value of G'

Table 3.19. Observed and corrected values for M_2-constituent

Analysis number	Central epoch (UT)	Observed M_2		Corrected M_2	
		G	κ	G	κ
1	Aug. 24, 00h, 1959	1.144	−1°.07	1.145	−1°.20
2	Sept. 14, 00h, 1959	1.132	−2.12	1.148	−1.97
3	Oct. 5, 00h, 1959	1.123	−5.21	1.140	−5.41
4	Oct. 26, 00h, 1959	1.149	−3.01	1.146	−3.20
5	Nov. 16, 00h, 1959	1.137	−3.37	1.150	−2.87
6	Dec. 7, 00h, 1959	1.164	−1.70	1.135	−3.09
7	Dec. 28, 00h, 1959	1.147	−2.15	1.143	−1.82
8	Jan. 18, 00h, 1960	1.157	−1.99	1.140	−2.70
9	Feb. 8, 00h, 1960	1.145	−1.61	1.145	−1.83
10	Feb. 29, 00h, 1960	1.130	−2.34	1.121	−2.37
11	Mar. 21, 00h, 1960	1.162	−1.57	1.154	−1.43
12	Apr. 11, 00h, 1960	1.177	−0.83	1.154	−1.53
13	May 2, 00h, 1960	1.144	−0.79	1.145	−1.42
14	May 23, 00h, 1960	1.150	−1.71	1.147	−1.49
15	June 13, 00h, 1960	1.092	−1.61	1.092	−1.61
16	July 4, 00h, 1960	1.130	−3.82	1.134	−3.82
17	July 25, 00h, 1960	1.147	−3.20	1.145	−3.10
Mean	Feb. 8, 00h, 1960	1.143 ±0.005	−2.24 ±0.29	1.140 ±0.004	−2.40 ±0.28

(by Lecolazet's method)

thus obtained may be considered as the one free from the influence of the oceanic tides. The value of G' obtained by the present one year's observation is in good agreement with that by the previous one month's observations.

The correction factors for temperature and pressure variations can also be obtained from Fig. 3.1. A conspicuous correlation cannot be found between the drift curve and atmospheric pressure variation, but it can be recognized between the drift curve and room temperature variation showing the opposite sense. The correction factor for temperature variation is obtained to be about -80 μgal/°C from Fig. 3.1. This value is about five times as large as the one obtained by applying the method of the least square.

(4) Corrected values of tidal factor of gravity and phase lag

Corrected values of the tidal factor of gravity and phase lag for M_2-constituent can easily be obtained by correcting the observational results with using the values of d, γ and δ. The corrected values thus obtained are shown in Table 3.19 with the observed ones, and also in Fig. 3.2. The maximum value to be corrected for temperature and pressure variations is 3% in tidal factor of gravity and 1.5° in phase lag, and a diversity in the results depending on difference of the observation time is about 5% in tidal factor of gravity and about 4° in phase lag.

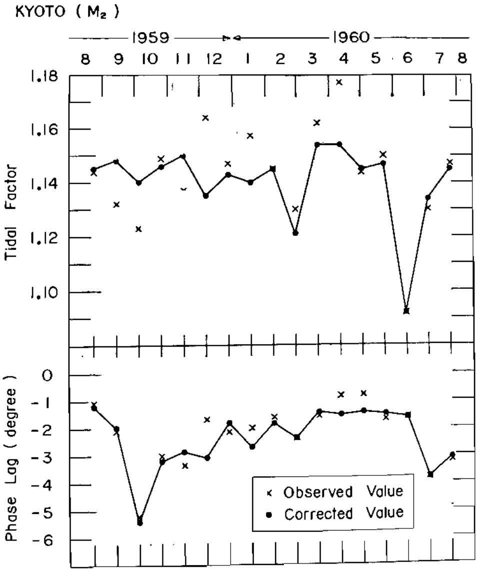

Fig. 3.2. Tidal factor of gravity and phase lag.

As could easily be seen from Fig. 3.2, only the value of tidal factor of analysis number 15 was exceedingly small. On the other hand, as shown in Table 3.6, error in determining the sensitivity of recording showed the maximum value at that time and reached ±2.4%. Furthermore, the recorded curve of gravity change was violently fluctuated in that period. Deducing from these facts, it was assumed that voltage fluctuations perhaps took place during the period of analysis number 15 and their effect was presumably included in the observed values. Therefore, except the value of analysis number 15 alone, the tidal factor of gravity obtained by correcting for temperature and pressure variations, showed a diversity with only 3% during a year, so far as M_2-constituent was concerned. If there existed time change in tidal factor of gravity, it should be included in this diversity together with the observational error. There was an error by ±1% in determining the sensitivity of recording used for calculation of the tidal factor of gravity and consequently the further discussion concerning the diversity of 3% was regarded to be insignificant. Taking the observational error into consideration, it was to be pointed out that values of analysis numbers 10 and 15 were too small, as for the tidal factor of gravity, and that the absolute value of analysis number 3 too large, as for the phase lag. It should be presumed that the other values were in good agreement with one another within a range of the observational error.

Generally speaking, if the influence caused by temperature and pressure variations was excluded from the observational results, sufficiently reliable results could be obtained by one month's observation so far as M_2-constituent was concerned. Concerning the cause for abnormal values of analysis numbers 3, 10 and 15, a detailed investigation is now in progress.

(5) Gravity observation during a passing of the Isewan typhoon

In the present one year's observation of the tidal variation of gravity, the largest and sudden change of atmospheric pressure was observed when the Isewan typhoon lashed on September 26, 1959. The minimum pressure observed in the observation room was 717.9 mmHg. Pressure difference observed between at that time and before 24 hours of that time amounted to about 37 mmHg. In the ordinary pressure variation, an influence caused by meteorological changes was observed superposing on the tidal variation of gravity and was practically too small to be distinguished from the gravity variation on the recording. But the sudden pressure change on that occasion partially deformed the proper curve of the tidal variation of gravity. The recorded curve of gravity change around the time of its typhoon, is shown in Fig. 3.3.

Hourly read values and their drift curve are shown in Fig. 3.4 with graphs of atmospheric pressure and room temperature in the corresponding period. The second graph in Fig. 3.4 is made up by applying the correction for meteorological changes to the hourly observed values using the correction

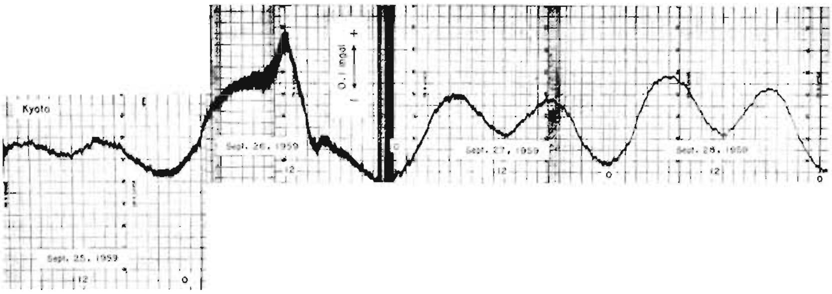

Fig. 3.3. Recorded curve obtained with the Askania gravimeter No. 111 when the Isewan typhoon lashed on September 26, 1959.
(Size about 1/7 of the original record)

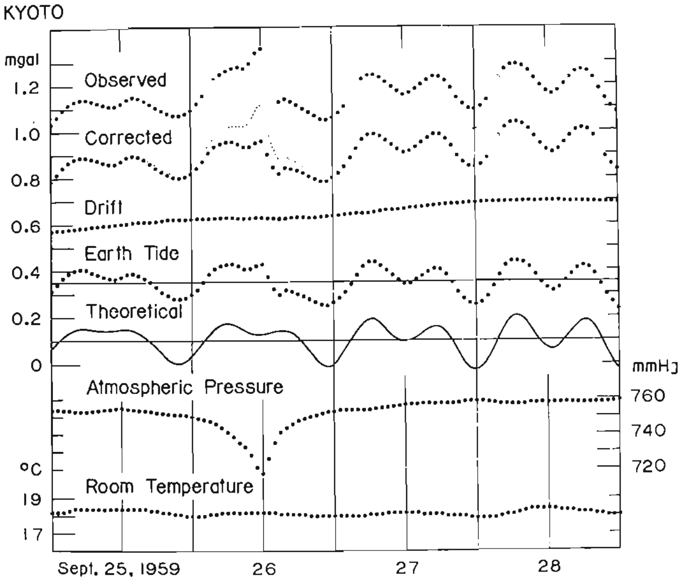

Fig. 3.4. Observed : Hourly read values from the original registrogram.
Corrected : Corrected hourly values free from influence of the meteorological changes.
Drift Drift curve determined by method (bde) (12, 30).
Earth tide Tidal variation of gravity obtained by subtracting 'drift' from 'corrected'.
Theoretical : Theoretical tidal curve at the observation station synthesised by a tide-predictor.

factors γ and δ above-obtained. In this correction, values of atmospheric pressure and room temperature at the time 24 hours before 12 h 00 m on September 26, when the minimum pressure was observed, were adopted as standards'. From the fourth graph in Fig. 3.4, it is regarded that some influences of the meteorological changes are yet remained and that a perfect elimination for them is necessitated.

(6) Correction of influence caused by meteorological changes in case of one month's observation

The author (1) tried to exclude mainly influence of the oceanic tides based on the data obtained by one month's observation of the tidal variation of gravity made previously at each of eleven stations in Japan. In that case, influence caused by temperature and pressure variations was kept included.

In the following, a trial to exclude the influence of meteorological changes from the analytical results for M_2-constituent obtained by the previous one month's observations, is described.

Let $R_0 \cos(\omega t+\varepsilon_0)$ be the vertical component of attraction with M_2-period arising from the oceanic tides within the distance of 1° in arc from the observation station in μgals. Adopting the above-described notation, one can put

$$\begin{aligned} d\cdot R\cos(\omega t+\varepsilon) &= G_0'\cdot R_1\cos(\omega t+\varepsilon_1)+a\cdot R_0\cos(\omega t+\varepsilon_0) \\ &\quad +\gamma\cdot R_T\cos(\omega t+\varepsilon_T)+\delta\cdot R_P\cos(\omega t+\varepsilon_P) \end{aligned} \tag{3.3}$$

for each station, where a is a correction factor for the influence of the oceanic tides and G_0' the tidal factor of gravity free from influences of the oceanic tides and meteorological changes.

Values of d, a, γ and δ have already been obtained as follows:

$$\left.\begin{array}{lcl} d=0.99934\,, & & a=\ \ 7.5\,, \\ \gamma=-17 & \text{and} & \delta=-3.9\,. \end{array}\right\} \tag{3.4}$$

Assuming that the values of γ and δ are available in the previous one month's observations, the results obtained by them can be corrected for various effects mentioned above, by using (3.3) and (3.4). Corrected values of the tidal factor of gravity and phase lag thus obtained are shown in Table 3.20 with their observed values.

As can easily be seen from Table 3.20, there exists a diversity of about 7% in the corrected tidal factor of gravity except the only one for Shiono-

Table 3.20. Observed and corrected values for M_2-constituent

Station	Central epoch (UT)	Observed M_2		Corrected M_2	
		G	κ	G	κ
Kyoto (I)	July 14, 18h, 1957	1.143	−1°.12	1.142	−1°.02
Matsushiro	Sept. 10, 18h, 1957	1.128	−0.89	1.126	−1.37
Omaezaki	Oct. 24, 18h, 1957	1.239	−2.15	1.133	−3.87
Shionomisaki	Feb. 3, 18h, 1958	1.141	−0.23	*0.913	−0.80
Naze	Apr. 16, 18h, 1958	1.197	−3.24	1.177	−3.30
Kyoto (II)	June 27, 18h, 1958	1.115	−1.24	1.130	−0.85
Nemuro	Aug. 17, 18h, 1958	1.191	+0.36	1.190	−1.21
Mizusawa	Oct. 1, 18h, 1958	1.110	+1.73	1.113	+1.69
Kanozan	Nov. 15, 18h, 1958	1.180	+0.55	1.140	+0.05
Tottori	Feb. 23, 18h, 1959	1.161	−6.44	1.128	−8.27
Aso	May 4, 18h, 1959	1.128	−2.70	1.123	−2.05
Mean	June 27, 18h, 1958	1.158	−1.40	1.140 ±0.008	−1.91 ±0.79

(by Lecolazet's method)

misaki where its value is abnormal. Since the influences of oceanic tides and meteorological changes have already been eliminated, it is regarded that the observational error and influence caused by difference of the geological structure around the station, if it exists, are included in the diversity of 7%. The relation between the corrected tidal factor of gravity and Bouguer anomaly is shown in Fig. 3.5.

The author (1) showed previously a relation between the tidal factor of gravity excluded of the influence caused by the oceanic tides alone and Bouguer anomaly. The relation between a tidal factor and Bouguer anomaly was more clear in Fig. 3.5 than in Fig. 1.7 of Part 1 (1). Mizusawa was treated as abnormal in Fig. 1.7, but there was no ground to so treat in Fig. 3.5.

Regarding the phase lag, as was shown in Table 3.20, the observed tide advanced the theoretical one at two stations of Mizusawa and Kanozan, while the situation was contrary at other stations. Especially, the phase lag obtained at Mizusawa was abnormal compared with the others. Therefore Mizusawa seemed to be a singular station. The author is now examining whether that was due to a peculiar geological structure at Mizusawa or a merely observational error. It is anyhow desirable to carry out observations again in the

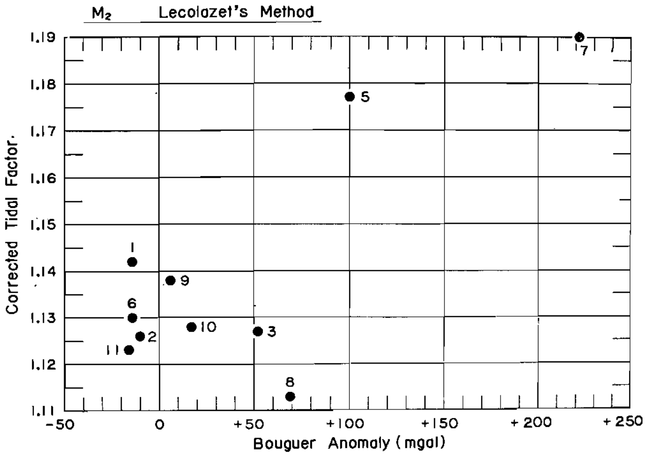

Fig. 3.5. Relation between the corrected tidal factor of gravity and Bouguer anomaly.

near future at Shionomisaki and Mizusawa where the observational results were abnormal.

In the previous one month's observations, the observation of the tidal variation of gravity at Kyoto was carried out twice. Namely, one was made at Kyoto (I) and the other at Kyoto (II). The distance between the observation room at Kyoto (I) and that at Kyoto (II) was about 300 metres, and the latter was the same room as in the present one year's observation. In the results obtained by these observations, a good agreement within a range of the observational error was recognized in both tidal factor of gravity and phase lag. Although the correction factor a for effect of the oceanic tides around the station was obtained by using the data containing influence of the meteorological changes in the previous one month's observations, the similar value could practically be obtained for a even if the data preliminarily eliminated with the influence caused by the meteorological changes were used.

(7) Definitive results

From various considerations mentioned above, the following definitive results are obtained for M_2-constituent.

In this table, the results for one year's observation are those at Kyoto situated at a distance of about 50 kilometres from the nearest seashore and considered to be free from influence of the oceanic tides. The results obtained at Kyoto may therefore be regarded as ones excluded of the oceanic tides

Table 3.21. Definitive values for M_2-constituent

	One year's observation	One month's observation
Elimination of drift	Pertzev's method	Pertzev's method
Harmonic analysis	Lecolazet's method	Lecolazet's method
Period of analysis	Aug. 1959—Aug. 1960 (366 days)	July 1957—May 1959 (330 days)
Number of analysis	17	11
Mean epoch	Feb. 8, 00h, 1960 (UT)	June 27, 18h, 1958 (UT)
$G(M_2)$	1.138 ± 0.005	1.139 ± 0.009
$\kappa(M_2)$	$-\ 2^\circ.40 \pm 0^\circ.28$	$-\ 1^\circ.91 \pm 0^\circ.79$

influence. Both values shown in Table 3.21 are entirely in agreement within a range of the observational error.

(8) Simultaneous observation with two Askania gravimeters at Kyoto

As for one of the causes of diversity in tidal factor of gravity and phase lag obtained at various stations in the world, a difference of instrument used is pointed out. In order to investigate this problem, a continuous observation with more than two gravimeters must necessarily be carried out at the same place for a long period.

Such observations were already made by P. Melchior (7), N. N. Pariisky (8, 22) and others in foreign countries. On the occasion of the previous one month's observations, the author carried out a simultaneous observation with two Askania gravimeters No. 105 and No. 111, set side by side in the same room, at the Kanozan Geodetic Observatory of the Geographical Survey Institute, where was a permanent observation station of the tidal variation of gravity by use of the Askania gravimeter No. 105. But a detailed comparison for results obtained by both gravimeters at the same period was not made due to two facts that the period of the simultaneous observation was only 34 days and that room temperature and atmospheric pressure variations were considerably violent. Then, a second simultaneous observation of the tidal variation of gravity was carried out at Kyoto by means of two Askania gravimeters mentioned above during a period of about seven months from January to August 1960. The objects of this observation were, as already described, to determine the reliability of the results obtained with one gravimeter alone by comparing in detail the results obtained simultaneously with two gravimeters placed in the same room, and to elucidate an original nature of the micro-change of gravity. The data obtained by the Askania gravimeter No. 105 are now in course of analysis by the Geographical Survey Institute. After completion of all analyses, results obtained by the simultaneous observation will be reported.

(9) Observation of free oscillations of the earth

In a period of the simultaneous observation of the tidal variation of gravity at Kyoto, the great Chilean earthquake of May 22, 1960 was observed with two Askania gravimeters No. 105 and No. 111 (**31**, **32**). Both gravimeters recorded clearly over several days large oscillations occured by the earthquake. These data obtained were already analysed, and some of free oscillations of the earth corresponding to the periods predicted by theoretical investigations were detected. Details concerning them would be reported in an another article (**33**) of the present study.

6. Summary

In the present article, results of a continuous observation of the tidal variation of gravity made in an underground special room of the Geophysical Institute of Kyoto University (where is the International Reference Station of Gravity in Japan) with the Askania gravimeter No. 111 during a period of about one year, from August 1959 to August 1960, were in detail described. Readings of the registrograms were made at every hour up to 0.1 mm (corresponding to about 0.25 μgal in gravity difference). Drift curve of the gravimeter was first of all eliminated from all the hourly read values by Pertzev's method. A harmonic analysis was made by Lecolazet's method for every 21 days by the help of an electronic computing machine 'IBM-650' and results for 17 analyses were obtained.

Results of the analysis showed that in spite of the observation at one station with the same gravimeter, there were diversities, even for M_2-constituent, by about 8% in tidal factor of gravity and by about 5° in phase lag due to difference in epoch of analysis and that their diversities were larger for the other constituents. As for the cause concerning the time change in values of the tidal factor of gravity and phase lag obtained at one station, it was suspected that an observational error, disturbance caused by meteorological changes, real time change of those values and others were probably responsible, and that the disturbance caused by meteorological changes was probably the most dominant. On the basis of an assumption that the observed tide was consisted of real gravimetric tide and apparent one caused by meteorological changes, correction factors for temperature and pressure variations were obtained by method of the least square using the observational results so as to fit them.

After various considerations, the following conclusions were obtained.

(1) Concerning the M_2-constituent, there were differences by 3% in tidal factor of gravity and by 4° in phase lag during a year, if the influence caused by temperature and pressure variations was excluded from the obtained values.

(2) The most reliable values of the tidal factor of gravity and phase lag for M_2-constituent at Kyoto, free from influences of temperature and pressure variations, were as follows :

$$G(M_2)=1.138\pm0.005 \quad \text{and} \quad \kappa(M_2)=-2^\circ.40\pm0^\circ.28\,. \qquad (3.5)$$

Among the diversities of 3% in tidal factor and 4° in phase lag after excluding the influence of meteorological changes, both observational error and real time change of their values were considered to be included. But it was impossible at the present stage to separate them. The following conclusion was also obtained by applying the correction factors for temperature and pressure variations found in the present discussion to the previous one month's observations.

(3) The most reliable values of the tidal factor of gravity and phase lag for M_2-constituent in Japan, free from influences of the oceanic tides, temperature and pressure variations, were as follows :

$$G(M_2)=1.139\pm0.009 \quad \text{and} \quad \kappa(M_2)=-1^\circ.91\pm0^\circ.79\,. \qquad (3.6)$$

According to the author's calculation, influence of the oceanic tides upon the tidal variation of gravity was negligibly small at Kyoto. It was therefore warrantable to be considered that the values in (3.5) were also free from an influence of oceanic tides. Both values obtained above were perfectly in agreement within a range of the observational error. From these considerations, the following conclusion was obtained.

(4) If the influences caused by the oceanic tides, temperature and pressure variations were excluded from the observed values, a suf-

ficiently reliable result could be obtained by one month's observation so far as M_2-constituent was concerned.

The value of the tidal factor of gravity obtained above was in good agreement with that obtained at some stations in Southeastern Asia, but it was far smaller than the tidal factor of gravity in Europe or that of theoretical investigations on earth tides. The difference between the observational results in Southeastern Asia and those in Europe was clearly recognized in both tidal factor of gravity and phase lag. A thorough investigation for the cause of its difference was a very interesting and attractive problem.

Furthermore, a detailed investigation for results obtained by a simultaneous observation with two Askania gravimeters at Kyoto and a trial to detect the micro-change of gravity, is now in progress and will be reported in near opportunity.

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Hourly observed values of gravity

Instrument : Askania Gs-11 gravimeter No. 111

Observation station : Kyoto
- Latitude – 35° 01.8′ N
- Longitude – 135° 47.2′ E
- Height – 59.9 metres

Observation room : International Reference Station of Gravity in Japan (at Kyoto)

Observation period : August 1, 1959 – August 17, 1960
(383 days)

August, 1959

Hour(UT) / Day	0	1	2	3	4	5	6	7	8	9	10
1	921	931	1018	1174	1337	1474	1580	1637	1669	1655	1613
2	915	862	898	987	1191	1430	1573	1665	1722	1726	1668
3	996	855	777	817	937	1173	1394	1534	1605	1634	1594
4	833	669	581	595	669	823	1028	1237	1374	1474	1520
5	2274	2132	2089	2119	2235	2394	2580	2800	3033	3230	3375
6	3725	3535	3360	3286	3283	3356	3553	3757	3917	3990	3998
7	3040	2879	2696	2522	2442	2433	2503	2630	2768	2900	3023
8	3205	3071	2920	2794	2712	2695	2750	2908	3117	3274	3394
9	2958	2851	2714	2577	2449	2350	2324	2358	2450	2580	2702
10	2646	2682	2664	2611	2543	2465	2401	2398	2443	2542	2654
11	2570	2663	2705	2719	2710	2684	2657	2641	2644	2671	2702
12	2479	2577	2681	2749	2799	2826	2827	2821	2811	2801	2801
13	2417	2525	2639	2736	2818	2886	2918	2918	2890	2839	2805
14	2439	2479	2565	2687	2824	2976	3094	3190	3184	3144	3081
15	2412	2412	2490	2683	2884	3040	3157	3224	3224	3141	3028
16	2538	2484	2519	2643	2790	2936	3080	3223	3320	3331	3253
17	2601	2444	2375	2451	2584	2829	3077	3233	3365	3431	3318
18	2848	2647	2491	2473	2588	2786	3004	3173	3325	3459	3461
19	3099	2936	2826	2754	2775	2903	3072	3241	3423	3583	3620
20	3268	3113	2993	2906	2895	2972	3101	3243	3421	3616	3665
21	3475	3290	3167	3073	3026	3055	3122	3232	3423	3603	3702
22	3665	3532	3363	3235	3184	3170	3203	3306	3455	3594	3651
23	3613	3573	3500	3394	3308	3270	3278	3349	3483	3571	3647
24	3623	3631	3611	3585	3538	3498	3501	3527	3588	3655	3687
25	3605	3638	3654	3661	3659	3654	3642	3652	3678	3709	3743
26	3619	3673	3723	3753	3757	3765	3766	3757	3748	3747	3754
27	3572	3639	3698	3750	3802	3849	3882	3887	3876	3853	3845
28	3540	3603	3677	3748	3835	3929	4045	4055	4013	3942	3878
29	3582	3618	3696	3795	3928	4058	4126	4183	4216	4200	4123
30	3592	3595	3664	3832	4033	4252	4401	4453	4449	4414	4354
31	3764	3713	3768	3911	4121	4328	4483	4560	4576	4551	4481

Station : Kyoto (II)

11	12	13	14	15	16	17	18	19	20	21	22	23
1566	1511	1467	1475	1507	1577	1629	1656	1647	1600	1505	1326	1119
1596	1525	1455	1398	1429	1497	1562	1617	1627	1606	1539	1416	1206
1502	1387	1248	1183	1172	1197	1301	1405	1474	1484	1429	1294	1095
1468	1405	1353	1355	1418	1557	1779	1999	2185	2339	2441	2470	2393
3395	3322	3206	3126	3101	3162	3293	3507	3690	3806	3892	3896	3840
3941	3812	3633	3389	3182	3075	3031	3049	3105	3173	3227	3231	3187
3059	3031	2945	2834	2752	2712	2709	2750	2824	2924	3063	3184	3261
3427	3406	3338	3204	3050	2877	2777	2734	2762	2840	2960	3017	3020
2807	2854	2833	2747	2644	2536	2404	2314	2270	2308	2399	2510	2590
2738	2784	2783	2748	2686	2590	2455	2314	2235	2189	2238	2321	2444
2747	2787	2811	2822	2811	2757	2684	2560	2437	2338	2259	2275	2374
2813	2848	2907	2957	2947	2906	2841	2767	2672	2552	2447	2373	2367
2797	2844	2918	3007	3117	3218	3238	3127	2971	2798	2678	2572	2483
3026	2990	3000	3049	3137	3189	3219	3213	3169	3051	2881	2669	2472
2930	2875	2876	2935	3022	3117	3222	3303	3282	3161	3011	2829	2668
3134	3025	2964	2936	2968	3058	3161	3238	3270	3231	3157	3020	2801
3192	3075	2990	2934	2944	3015	3115	3216	3316	3376	3314	3184	3040
3329	3181	3083	3031	3003	3036	3115	3221	3385	3519	3518	3399	3238
3556	3378	3230	3123	3068	3065	3101	3202	3323	3501	3586	3578	3456
3628	3488	3314	3172	3082	3041	3073	3143	3260	3420	3553	3624	3622
3703	3638	3505	3322	3192	3132	3116	3162	3247	3398	3586	3678	3709
3680	3662	3594	3493	3355	3232	3144	3137	3215	3325	3463	3571	3623
3697	3702	3652	3583	3485	3391	3298	3236	3233	3294	3403	3514	3582
3717	3734	3726	3680	3612	3516	3421	3346	3301	3322	3388	3462	3536
3771	3792	3792	3780	3751	3702	3645	3589	3512	3473	3462	3499	3561
3767	3785	3815	3827	3804	3766	3714	3657	3590	3552	3516	3500	3512
3838	3839	3858	3882	3867	3854	3830	3784	3697	3623	3551	3497	3499
3845	3829	3846	3888	3982	4069	4088	4012	3906	3797	3719	3656	3591
4049	4023	4030	4084	4139	4201	4254	4255	4194	4102	3909	3755	3657
4251	4164	4132	4142	4228	4321	4415	4462	4454	4385	4265	4062	3873
4373	4252	4197	4180	4224	4344	4452	4529	4570	4530	4456	4301	4094

Unit in 0.1 mm

September, 1959

Hour(UT) Day	0	1	2	3	4	5	6	7	8	9	10
1	3882	3772	3771	3846	4059	4292	4473	4588	4667	4668	4601
2	4186	4011	3897	3917	4085	4264	4474	4621	4747	4781	4702
3	4369	4182	4023	3983	4067	4248	4423	4590	4745	4877	4849
4	4575	4430	4290	4192	4226	4371	4535	4692	4859	5027	5062
5	4824	4656	4549	4464	4407	4449	4539	4674	4836	5032	5135
6	4977	4828	4707	4627	4593	4583	4633	4719	4856	5078	5169
7	5134	5094	4974	4864	4778	4731	4732	4768	4870	5010	5134
8	5038	5091	5083	5024	4948	4894	4886	4906	4978	5067	5136
9	4908	5008	5097	5141	5150	5135	5097	5071	5073	5095	5126
10	4731	4851	4978	5115	5204	5261	5280	5264	5221	5170	5149
11	4709	4801	4954	5132	5291	5370	5399	5391	5345	5277	5215
12	4693	4781	4902	5104	5288	5397	5476	5500	5482	5424	5352
13	4715	4733	4840	5023	5269	5481	5590	5642	5648	5613	5511
14	4940	4894	4942	5093	5311	5530	5671	5734	5751	5707	5620
15	5109	4997	4952	5081	5250	5493	5673	5798	5854	5848	5730
16	5411	5259	5172	5209	5317	5456	5619	5780	5944	6010	5878
17	5597	5467	5397	5390	5444	5554	5748	5995	6138	6196	6133
18	5757	5567	5481	5452	5445	5516	5679	5893	6039	6103	6092
19	5969	5817	5667	5565	5553	5621	5773	5924	6055	6142	6164
20	6043	5941	5809	5694	5632	5674	5780	5897	6032	6103	6141
21	6114	6056	5979	5905	5864	5844	5884	5962	6065	6156	6183
22	6127	6119	6092	6063	6031	6006	5998	6035	6095	6158	6187
23	6123	6151	6166	6163	6153	6146	6155	6169	6197	6215	6245
24	6175	6260	6310	6339	6344	6331	6305	6286	6266	6260	6269
25	6139	6257	6375	6464	6525	6557	6558	6532	6503	6467	6444
26	6371	6484	6621	6776	6897	6981	7046	7093	7110	7089	7171
27	6234	6311	6422	6571	6737	6887	6954	6961	6921	6842	6754
28	6362	6417	6523	6698	6905	7057	7128	7141	7108	7030	6900
29	6322	6307	6383	6533	6738	6953	7093	7133	7106	7012	6843
30	6356	6297	6344	6461	6653	6896	7093	7165	7184	7133	6984
31											

Station : Kyoto (II)

11	12	13	14	15	16	17	18	19	20	21	22	23
4513	4409	4311	4252	4262	4369	4492	4610	4714	4721	4652	4529	4370
4572	4445	4329	4226	4212	4301	4417	4533	4653	4763	4763	4654	4523
4691	4544	4441	4327	4271	4270	4366	4510	4642	4790	4892	4851	4723
4959	4774	4621	4498	4385	4367	4420	4528	4668	4819	4943	5045	5001
5074	4919	4739	4585	4465	4379	4383	4463	4582	4698	4847	5002	5066
5184	5113	4960	4718	4608	4534	4478	4487	4562	4657	4791	4957	5099
5185	5168	5075	4931	4763	4643	4555	4494	4505	4678	4682	4807	4914
5189	5218	5193	5099	4958	4817	4703	4602	4572	4594	4642	4711	4798
5163	5197	5212	5182	5112	5012	4873	4762	4661	4578	4550	4571	4632
5143	5168	5224	5252	5244	5209	5141	4987	4829	4739	4676	4639	4642
5154	5149	5209	5275	5314	5331	5321	5263	5171	5010	4841	4753	4694
5253	5205	5222	5284	5362	5443	5471	5465	5432	5331	5165	4992	4795
5395	5323	5283	5301	5415	5508	5589	5647	5675	5615	5486	5295	5098
5509	5347	5275	5286	5361	5481	5606	5685	5726	5729	5646	5501	5311
5609	5492	5389	5329	5360	5456	5594	5722	5829	5881	5808	5691	5566
5668	5525	5416	5372	5379	5431	5553	5728	5959	6053	6064	6002	5838
5997	5768	5575	5485	5440	5455	5535	5683	5900	6033	6089	6069	5972
5993	5823	5614	5454	5365	5359	5414	5556	5773	5956	6071	6113	6073
6114	6004	5802	5593	5478	5431	5454	5533	5673	5883	6033	6085	6085
6115	6018	5859	5675	5531	5445	5421	5491	5613	5776	5932	6044	6122
6175	6128	6043	5928	5780	5614	5546	5540	5599	5734	5874	6018	6106
6196	6174	6133	6048	5940	5803	5711	5661	5665	5753	5854	5965	6053
6251	6238	6218	6176	6103	6031	5940	5864	5825	5834	5893	5979	6081
6290	6317	6320	6294	6242	6170	6090	6009	5929	5877	5873	5939	6028
6442	6492	6559	6595	6581	6538	6484	6415	6364	6314	6281	6276	6303
7347	7425	7063	6700	6501	6555	6506	6446	6385	6324	6257	6202	6190
6680	6625	6649	6718	6794	6871	6933	6928	6852	6732	6562	6454	6381
6771	6675	6627	6682	6793	6903	7002	7041	7013	6901	6715	6544	6413
6636	6518	6490	6507	6580	6758	6923	7020	7060	7012	6883	6653	6473
6796	6570	6482	6454	6500	6653	6878	7065	7135	7163	7109	6977	6748

Unit in 0.1 mm

Gravity

October, 1959

Hour(UT) Day	0	1	2	3	4	5	6	7	8	9	10
1	6537	6424	6402	6493	6652	6867	7102	7222	7264	7251	7185
2	6993	6805	6709	6716	6843	7021	7200	7348	7493	7485	7383
3	7318	7201	7106	7055	7125	7224	7350	7537	7743	7824	7774
4	7643	7443	7297	7243	7233	7256	7360	7513	7664	7749	7752
5	7861	7780	7658	7528	7427	7363	7429	7586	7770	7872	7887
6	7605	7602	7515	7433	7380	7357	7358	7400	7483	7613	7737
7	7651	7767	7803	7755	7644	7503	7397	7335	7325	7349	7411
8	7281	7355	7416	7483	7501	7496	7454	7420	7405	7415	7465
9	7164	7245	7333	7434	7538	7546	7505	7428	7355	7306	7275
10	6869	7013	7131	7211	7268	7296	7294	7276	7219	7154	7099
11	6566	6696	6844	7014	7167	7234	7263	7252	7218	7153	7072
12	6542	6612	6762	6942	7115	7214	7261	7261	7227	7162	7043
13	6561	6551	6632	6855	7070	7191	7282	7318	7296	7220	7101
14	6517	6452	6456	6517	6695	6890	7047	7100	7060	6962	6801
15	6555	6472	6468	6545	6718	6912	7082	7191	7221	7173	7099
16	7086	6997	6946	6969	7071	7190	7333	7513	7656	7675	7559
17	7872	7777	7697	7645	7637	7697	7768	7843	7905	7908	7841
18	7504	7340	7166	7041	7067	7148	7287	7442	7577	7627	7592
19	7391	7252	7118	7048	7024	7035	7099	7190	7279	7346	7328
20	7253	7197	7133	7091	7073	7093	7131	7195	7284	7359	7367
21	7404	7414	7371	7291	7230	7204	7251	7347	7449	7517	7535
22	7369	7412	7403	7368	7331	7281	7248	7271	7316	7362	7401
23	7311	7393	7461	7472	7451	7421	7384	7364	7356	7391	7428
24	7319	7476	7583	7624	7625	7594	7570	7535	7493	7459	7434
25	7258	7396	7535	7649	7716	7741	7722	7653	7566	7470	7400
26	7240	7358	7514	7676	7774	7841	7838	7772	7678	7569	7463
27	7293	7390	7535	7732	7863	7943	7969	7904	7788	7655	7524
28	7317	7363	7492	7663	7839	7941	7978	7976	7916	7782	7622
29	7424	7444	7548	7706	7859	7988	8074	8106	8051	7926	7771
30	7538	7459	7466	7596	7748	7903	8000	8051	8052	7962	7823
31	7766	7659	7619	7668	7784	7916	8041	8157	8222	8143	7961

Station : Kyoto (II)

11	12	13	14	15	16	17	18	19	20	21	22	23
7033	6825	6613	6503	6515	6613	6852	7093	7235	7322	7322	7273	7171
7242	7071	6893	6742	6671	6773	6950	7158	7333	7483	7583	7560	7448
7624	7373	7196	7026	6948	6922	7018	7159	7363	7598	7767	7827	7794
7656	7536	7415	7281	7154	7075	7059	7125	7267	7426	7583	7749	7855
7844	7762	7623	7445	7265	7105	7020	7031	7105	7213	7333	7463	7564
7761	7625	7442	7306	7207	7112	7038	7034	7064	7127	7216	7328	7488
7456	7435	7378	7304	7215	7101	7007	6897	6865	6914	7015	7116	7201
7498	7500	7453	7387	7315	7240	7180	7117	7047	7005	6994	7026	7091
7259	7264	7270	7260	7245	7206	7164	7077	6962	6853	6774	6746	6767
7038	7015	7024	7048	7071	7094	7087	7045	6934	6795	6675	6567	6520
6983	6914	6912	6982	7059	7111	7142	7151	7104	7018	6885	6695	6577
6909	6797	6735	6787	6930	7055	7151	7183	7172	7119	7013	6862	6689
6916	6748	6611	6602	6730	6862	7007	7107	7131	7093	7008	6849	6659
6551	6390	6288	6266	6350	6480	6679	6892	7032	7071	7030	6901	6724
6937	6706	6531	6452	6500	6650	6901	7113	7247	7321	7330	7283	7195
7371	7218	7075	6947	6941	7046	7264	7536	7750	7895	7989	7996	7961
7722	7518	7288	7078	6985	6968	7045	7247	7437	7588	7671	7690	7612
7452	7237	7034	6880	6805	6789	6845	6938	7138	7329	7466	7527	7491
7233	7120	6990	6823	6669	6562	6593	6697	6850	7013	7134	7216	7253
7286	7184	7084	6971	6863	6764	6754	6819	6936	7043	7144	7249	7337
7488	7362	7225	7114	7016	6936	6870	6881	6939	7013	7094	7193	7291
7407	7350	7261	7169	7073	7008	6948	6931	6950	6988	7058	7133	7219
7449	7445	7396	7311	7231	7160	7105	7048	7034	7048	7078	7138	7208
7439	7455	7473	7452	7394	7319	7257	7198	7140	7108	7098	7118	7178
7390	7419	7449	7490	7522	7528	7485	7414	7332	7259	7200	7168	7175
7395	7405	7470	7555	7637	7693	7712	7682	7603	7487	7376	7296	7267
7407	7341	7370	7473	7613	7736	7815	7847	7811	7733	7593	7444	7344
7466	7327	7289	7383	7556	7722	7846	7936	7968	7932	7845	7695	7546
7550	7341	7279	7292	7408	7604	7789	7936	8015	8026	7957	7836	7676
7639	7389	7217	7164	7201	7409	7660	7872	8001	8098	8101	8016	7893
7759	7503	7291	7153	7140	7239	7460	7730	7935	8078	8151	8148	8058

Unit in 0.1 mm

Gravity

November, 1959

Hour(UT) Day	0	1	2	3	4	5	6	7	8	9	10
1	7923	7811	7723	7710	7798	7910	8044	8172	8284	8262	8111
2	8190	8053	7951	7892	7881	7947	8040	8162	8304	8342	8235
3	8241	8130	8009	7942	7912	7927	7993	8110	8270	8372	8379
4	8266	8249	8161	8078	8010	7961	7970	8019	8099	8183	8251
5	8284	8366	8388	8361	8308	8232	8181	8204	8264	8321	8371
6	8344	8461	8510	8525	8516	8467	8414	8369	8328	8328	8341
7	8189	8329	8453	8499	8515	8482	8407	8325	8262	8220	8198
8	8096	8246	8388	8502	8564	8568	8548	8498	8418	8308	8228
9	8192	8288	8405	8532	8602	8637	8626	8578	8497	8394	8295
10	8207	8292	8431	8559	8647	8698	8705	8658	8577	8477	8315
11	8276	8316	8416	8547	8667	8750	8805	8785	8691	8576	8445
12	8465	8460	8519	8635	8799	8996	9115	9154	9108	8898	8715
13	8635	8585	8582	8625	8728	8877	9028	9074	9038	8911	8754
14	8744	8678	8662	8689	8775	8900	8984	9027	9008	8951	8823
15	8814	8734	8705	8730	8796	8884	8967	9032	9059	9011	8914
16	8969	8901	8840	8803	8828	8903	8990	9063	9121	9127	9051
17	9032	8971	8911	8881	8891	8923	8977	9049	9113	9159	9124
18	9196	9153	9101	9063	9050	9058	9106	9155	9211	9263	9261
19	9319	9268	9198	9138	9098	9089	9099	9151	9222	9292	9289
20	9282	9282	9232	9172	9118	9074	9083	9111	9148	9180	9197
21	9234	9298	9319	9302	9253	9213	9179	9151	9149	9163	9184
22	9068	9143	9211	9239	9232	9191	9139	9100	9077	9091	9139
23	9885	10004	10124	10200	10206	10164	10098	10042	9992	9972	9995
24	10055	10492	10626	10724	10773	10752	10681	10528	10389	10254	10123
25	9579	9672	9808	9959	10065	10113	10065	9957	9835	9726	9616
26	9719	9796	9961	10126	10276	10357	10346	10236	10081	9899	9749
27	9650	9665	9736	9858	10009	10135	10153	10105	10003	9849	9627
28	9739	9706	9755	9841	9962	10091	10165	10166	10098	9981	9764
29	9862	9783	9790	9870	9979	10096	10217	10297	10237	10107	9955
30	10052	9965	9906	9910	9956	10055	10206	10352	10395	10276	10084
31											

Station : Kyoto (II)

11	12	13	14	15	16	17	18	19	20	21	22	23
7958	7760	7569	7380	7281	7300	7463	7717	7927	8120	8301	8392	8315
8078	7875	7685	7450	7270	7228	7296	7483	7711	7901	8062	8208	8278
8252	8095	7915	7737	7547	7403	7378	7458	7602	7775	7918	8069	8200
8247	8121	7984	7837	7700	7575	7488	7499	7602	7732	7871	8007	8148
8400	8352	8237	8109	7992	7881	7803	7751	7759	7804	7884	7993	8148
8367	8377	8348	8298	8213	8122	8008	7907	7864	7848	7871	7949	8071
8208	8247	8282	8308	8298	8246	8178	8097	8017	7942	7908	7914	7977
8188	8228	8293	8349	8388	8409	8402	8374	8321	8239	8144	8093	8108
8226	8197	8228	8318	8426	8500	8557	8561	8536	8466	8376	8276	8208
8194	8126	8136	8214	8335	8451	8557	8618	8627	8576	8500	8406	8302
8308	8198	8177	8233	8335	8476	8605	8692	8745	8751	8681	8612	8525
8533	8390	8322	8326	8405	8536	8673	8820	8965	8995	8925	8816	8706
8589	8435	8277	8249	8317	8457	8608	8777	8967	9082	9076	8982	8858
8613	8350	8183	8112	8113	8204	8377	8633	8856	8947	8983	8965	8894
8773	8534	8322	8195	8183	8244	8375	8609	8845	8982	9074	9074	9030
8921	8741	8536	8320	8246	8247	8347	8561	8762	8942	9041	9096	9089
9012	8879	8714	8536	8403	8349	8410	8575	8769	8955	9083	9172	9212
9175	9049	8901	8741	8619	8560	8553	8622	8808	8973	9104	9209	9277
9222	9126	9022	8902	8776	8671	8611	8656	8743	8879	9011	9134	9232
9185	9128	9057	8970	8872	8771	8699	8674	8720	8808	8923	9039	9141
9178	9145	9095	9027	8946	8858	8770	8719	8716	8751	8829	8920	8999
9183	9238	9287	9338	9385	9411	9394	9363	9370	9410	9471	9583	9733
10049	10122	10193	10259	10310	10305	10264	10185	10099	10051	10054	10109	10207
10016	10005	10037	10074	10104	10105	10058	9973	9872	9775	9665	9590	9554
9565	9563	9597	9712	9823	9964	10046	10074	10034	9943	9799	9714	9684
9617	9502	9478	9552	9686	9826	9961	10068	10102	10018	9906	9790	9695
9412	9265	9220	9265	9406	9634	9826	9977	10056	10068	10026	9937	9836
9512	9281	9161	9140	9246	9421	9681	9902	10061	10140	10130	10062	9956
9726	9511	9269	9170	9194	9328	9552	9805	10011	10169	10253	10233	10142
9897	9655	9378	9225	9146	9216	9378	9651	9896	10088	10245	10333	10304

Unit in 0.1 mm

December, 1959

Hour(UT) Day	0	1	2	3	4	5	6	7	8	9	10
1	10190	10115	10036	9995	10016	10108	10238	10376	10530	10496	10357
2	10882	10844	10788	10739	10710	10744	10829	10977	11145	11179	11116
3	10822	10749	10658	10581	10522	10470	10453	10469	10521	10556	10570
4	10596	10624	10601	10559	10498	10428	10391	10395	10430	10462	10495
5	10531	10582	10609	10615	10596	10530	10460	10414	10403	10423	10451
6	10692	10769	10840	10851	10791	10717	10651	10570	10518	10493	10487
7	10641	10726	10817	10867	10857	10793	10694	10592	10512	10447	10419
8	10556	10625	10701	10841	10959	10990	10950	10838	10730	10636	10579
9	10135	10153	10199	10284	10313	10258	10185	10073	9944	9795	9659
10	10057	10101	10189	10290	10383	10461	10465	10380	10263	10130	10020
11	10180	10200	10253	10344	10453	10604	10639	10599	10489	10299	10153
12	10340	10330	10369	10491	10638	10739	10806	10799	10736	10618	10459
13	10712	10689	10709	10773	10855	10935	11006	11052	11036	10923	10761
14	10724	10667	10662	10721	10792	10902	10999	11059	11060	10977	10854
15	11299	11209	11151	11159	11230	11345	11464	11541	11563	11532	11432
16	11257	11163	11102	11066	11069	11127	11216	11294	11335	11325	11246
17	11175	11103	11019	10964	10932	10946	10996	11054	11122	11122	11071
18	11080	11052	11012	10979	10952	10929	10956	11016	11070	11114	11124
19	11198	11209	11172	11132	11086	11068	11075	11104	11155	11212	11244
20	11354	11402	11366	11300	11225	11169	11125	11104	11104	11132	11153
21	11199	11234	11242	11227	11165	11104	11053	11024	11005	11005	11027
22	11157	11224	11271	11273	11251	11180	11089	11015	10971	10949	10953
23	10956	11057	11116	11142	11132	11071	10961	10841	10738	10645	10580
24	10447	10534	10635	10685	10677	10570	10412	10247	10067	9942	9849
25	10466	10620	10830	10978	11078	11139	11140	11090	10977	10822	10676
26	11220	11270	11400	11577	11683	11721	11698	11620	11491	11279	11041
27	11489	11483	11557	11661	11749	11841	11903	11890	11810	11654	11451
28	11709	11686	11696	11783	11878	11979	12048	12085	11997	11850	11639
29	11777	11702	11687	11716	11789	11875	11964	11991	11991	11874	11715
30	11851	11752	11663	11643	11704	11799	11896	11997	12073	12065	11965
31	12145	12038	11934	11853	11844	11859	11934	12075	12219	12283	12235

Station : Kyoto (II)

11	12	13	14	15	16	17	18	19	20	21	22	23
10178	9989	9794	9590	9468	9468	9639	9871	10108	10386	10605	10782	10868
10949	10733	10524	10320	10122	9948	9943	10057	10238	10429	10596	10742	10839
10545	10421	10220	9994	9820	9676	9601	9637	9758	9958	10147	10337	10504
10520	10493	10416	10280	10088	9927	9827	9806	9836	9919	10062	10253	10399
10486	10503	10495	10469	10444	10410	10383	10357	10356	10379	10455	10528	10611
10502	10516	10525	10539	10548	10538	10511	10487	10473	10466	10485	10523	10569
10442	10516	10567	10608	10632	10639	10619	10580	10529	10487	10465	10480	10508
10580	10606	10630	10669	10698	10699	10674	10618	10542	10440	10325	10224	10162
9577	9542	9587	9702	9834	9983	10097	10157	10178	10151	10102	10060	10041
9889	9809	9799	9889	10019	10134	10230	10320	10354	10365	10321	10248	10202
10011	9910	9862	9906	10019	10140	10283	10439	10599	10658	10605	10513	10399
10304	10191	10105	10124	10226	10377	10531	10699	10822	10888	10896	10852	10781
10551	10359	10242	10188	10205	10308	10467	10615	10737	10838	10899	10882	10804
10681	10519	10350	10242	10208	10335	10556	10776	10983	11192	11329	11400	11369
11295	11089	10807	10637	10553	10553	10643	10813	11047	11250	11343	11373	11339
11075	10817	10566	10399	10277	10246	10336	10515	10705	10925	11090	11213	11226
10989	10869	10680	10461	10324	10261	10272	10372	10552	10772	10932	11042	11088
11074	10963	10814	10657	10506	10385	10347	10431	10587	10777	10966	11079	11155
11239	11178	11080	10958	10844	10738	10674	10688	10780	10908	11041	11154	11256
11154	11142	11076	10984	10883	10754	10659	10628	10647	10752	10879	11014	11125
11042	11051	11041	10999	10933	10834	10742	10664	10655	10718	10813	10935	11045
10979	11020	11048	11048	11023	10970	10880	10794	10719	10671	10695	10755	10841
10589	10633	10672	10709	10736	10735	10691	10615	10540	10477	10421	10390	10400
9823	9877	9962	10062	10161	10249	10337	10386	10399	10375	10345	10350	10386
10572	10595	10694	10820	10976	11115	11266	11388	11441	11409	11345	11278	11218
10891	10821	10842	10932	11084	11320	11540	11657	11750	11752	11712	11659	11573
11208	10992	10908	10921	11023	11232	11471	11687	11840	11908	11911	11860	11781
11368	11111	10938	10855	10867	11029	11256	11523	11742	11880	11969	11959	11878
11484	11195	10968	10795	10755	10854	11006	11245	11544	11773	11905	11948	11934
11792	11583	11321	11107	10959	10934	11041	11274	11552	11798	11984	12128	12195
12086	11899	11712	11513	11330	11199	11217	11354	11568	11757	11963	12114	12219

Unit in 0.1 mm

Gravity

January, 1960

Day \ Hour(UT)	0	1	2	3	4	5	6	7	8	9	10
1	12195	12104	12012	11934	11874	11837	11850	11899	11973	12043	12064
2	12123	12134	12054	11945	11873	11829	11793	11822	11886	11976	12027
3	12114	12167	12160	12094	12009	11929	11873	11854	11884	11929	11986
4	12119	12231	12272	12231	12139	12019	11932	11886	11871	11877	11915
5	12155	12247	12273	12254	12194	12064	11923	11815	11764	11725	11705
6	11875	11937	11999	12054	12062	11974	11863	11777	11708	11647	11617
7	11917	12004	12100	12202	12252	12237	12179	12071	11938	11825	11750
8	12021	12073	12178	12271	12341	12351	12300	12187	12007	11863	11777
9	12049	12060	12147	12250	12320	12347	12351	12294	12179	12012	11851
10	12167	12152	12202	12271	12342	12383	12406	12386	12323	12230	12063
11	12293	12250	12283	12339	12392	12441	12474	12467	12412	12312	12149
12	12285	12217	12192	12230	12295	12362	12411	12445	12441	12359	12213
13	12322	12251	12202	12222	12277	12355	12417	12465	12486	12439	12325
14	12418	12345	12297	12292	12313	12357	12425	12490	12537	12518	12440
15	12317	12237	12149	12086	12073	12109	12194	12280	12356	12374	12345
16	12390	12327	12260	12206	12186	12207	12261	12328	12399	12437	12450
17	12691	12659	12596	12517	12451	12448	12491	12598	12752	12879	12945
18	13078	13050	12991	12924	12822	12719	12690	12732	12804	12890	12975
19	13334	13360	13337	13296	13219	13154	13112	13104	13155	13238	13280
20	13312	13330	13323	13284	13189	13074	12948	12864	12804	12788	12825
21	13049	13151	13175	13141	13062	12943	12783	12652	12587	12549	12552
22	12923	13032	13096	13083	13037	12942	12802	12649	12486	12356	12297
23	12806	12884	12942	12981	12995	12955	12856	12734	12555	12361	12255
24	12770	12804	12874	12950	12986	12995	12965	12877	12713	12503	12315
25	12822	12822	12874	12966	13055	13115	13128	13077	12977	12826	12600
26	12945	12914	12916	12984	13063	13147	13196	13195	13125	13002	12800
27	12997	12924	12886	12912	13010	13106	13214	13282	13293	13183	13033
28	13053	12951	12863	12853	12902	12983	13078	13186	13271	13274	13164
29	13124	13009	12892	12850	12853	12898	12978	13106	13234	13358	13364
30	13806	13723	13578	13452	13398	13413	13514	13640	13767	13926	13947
31	13712	13646	13534	13424	13306	13247	13284	13354	13439	13537	13594

Station : Kyoto (II)

11	12	13	14	15	16	17	18	19	20	21	22	23
12022	11894	11769	11608	11396	11224	11181	11247	11397	11604	11784	11931	12053
12035	12002	11896	11767	11632	11486	11366	11363	11447	11587	11733	11881	12006
12060	12087	12027	11932	11833	11727	11657	11605	11613	11694	11803	11904	12014
11954	11984	12004	11984	11918	11849	11799	11769	11772	11798	11838	11924	12024
11714	11751	11793	11824	11825	11812	11790	11761	11735	11728	11739	11767	11807
11624	11656	11693	11747	11791	11830	11850	11858	11854	11844	11826	11834	11858
11697	11679	11718	11780	11852	11930	12001	12050	12081	12058	12010	11989	11985
11717	11698	11712	11770	11858	11936	12039	12158	12245	12250	12202	12139	12080
11699	11603	11579	11616	11723	11872	12051	12208	12299	12332	12303	12253	12203
11857	11718	11672	11676	11774	11953	12122	12260	12371	12443	12442	12402	12348
11923	11722	11603	11570	11614	11735	11945	12166	12329	12416	12451	12412	12351
11985	11780	11622	11531	11533	11641	11833	12051	12257	12384	12441	12435	12392
12168	11927	11738	11616	11580	11629	11776	12042	12260	12406	12497	12518	12490
12336	12166	11918	11706	11603	11586	11679	11847	12093	12258	12359	12407	12383
12253	12086	11837	11647	11506	11455	11521	11654	11893	12126	12294	12391	12429
12430	12351	12245	12063	11830	11718	11698	11769	11989	12245	12416	12534	12637
12941	12873	12724	12523	12409	12330	12290	12331	12419	12560	12819	12989	13067
13035	13025	12955	12795	12626	12528	12476	12495	12566	12725	12927	13123	13245
13304	13313	13284	13230	13155	13044	12919	12876	12885	12954	13066	13186	13274
12894	12949	12994	12995	12926	12844	12763	12703	12652	12673	12738	12835	12940
12583	12652	12743	12816	12842	12830	12791	12752	12722	12712	12731	12763	12823
12296	12334	12414	12551	12679	12767	12813	12832	12807	12774	12753	12735	12747
12194	12174	12244	12337	12485	12636	12793	12887	12923	12914	12873	12813	12765
12205	12136	12138	12213	12363	12554	12784	12925	13000	13025	13003	12948	12865
12362	12235	12177	12195	12285	12456	12739	12935	13078	13137	13137	13075	13012
12508	12275	12125	12081	12145	12281	12476	12766	12974	13105	13159	13137	13075
12844	12578	12353	12230	12182	12253	12434	12693	12923	13062	13164	13202	13152
13023	12834	12583	12353	12253	12240	12338	12540	12833	13024	13154	13214	13205
13223	13092	12953	12796	12673	12644	12743	12913	13102	13358	13585	13753	13829
13836	13688	13534	13324	13087	12947	12916	13030	13206	13416	13565	13671	13736
13594	13536	13426	13277	13095	12961	12896	12926	13036	13196	13375	13496	13565

Unit in 0.1 mm

February, 1960

Hour(UT) / Day	0	1	2	3	4	5	6	7	8	9	10
1	13563	13514	13447	13336	13198	13066	12996	13017	13084	13198	13303
2	13509	13514	13478	13398	13283	13174	13073	13053	13093	13171	13275
3	13483	13510	13491	13448	13372	13269	13141	13074	13053	13060	13095
4	13463	13498	13491	13451	13382	13304	13203	13122	13033	12987	13003
5	13390	13441	13476	13503	13479	13436	13371	13292	13199	13132	13090
6	13502	13521	13550	13599	13614	13611	13572	13488	13404	13298	13181
7	13500	13529	13580	13627	13663	13672	13647	13584	13502	13382	13253
8	13561	13569	13614	13686	13761	13808	13805	13743	13647	13538	13416
9	13555	13537	13550	13595	13670	13763	13814	13794	13739	13623	13506
10	13562	13511	13498	13520	13590	13680	13738	13765	13715	13616	13492
11	13618	13535	13515	13531	13567	13658	13770	13907	13896	13797	13666
12	13758	13635	13572	13563	13607	13721	13881	14015	14086	14074	13932
13	13867	13736	13611	13591	13611	13684	13843	14036	14144	14178	14148
14	14081	13928	13797	13692	13669	13748	13861	13990	14095	14137	14139
15	14064	13948	13794	13650	13561	13538	13614	13753	13921	14034	14094
16	14149	14090	13991	13852	13719	13672	13700	13780	13913	14045	14110
17	14275	14235	14148	14063	13950	13842	13783	13809	13893	13995	14088
18	14294	14281	14222	14141	14042	13919	13818	13747	13769	13835	13923
19	14273	14296	14273	14216	14136	14041	13959	13875	13816	13794	13846
20	14295	14347	14372	14373	14314	14224	14126	14034	13956	13896	13870
21	14185	14218	14238	14252	14244	14183	14094	13988	13856	13696	13577
22	14024	14055	14124	14186	14249	14276	14261	14209	14109	13969	13775
23	14249	14282	14369	14507	14644	14744	14776	14744	14647	14486	14264
24	14445	14376	14407	14506	14598	14696	14760	14771	14734	14589	14345
25	14520	14416	14381	14429	14536	14661	14785	14848	14851	14781	14647
26	14606	14496	14395	14378	14457	14606	14731	14839	14909	14909	14839
27	14665	14501	14349	14265	14297	14426	14595	14721	14818	14866	14823
28	14765	14645	14509	14384	14341	14389	14516	14646	14775	14848	14844
29	14819	14698	14574	14471	14380	14357	14452	14573	14706	14812	14889
30											
31											

Station : Kyoto (II)

11	12	13	14	15	16	17	18	19	20	21	22	23
13367	13392	13325	13224	13074	12936	12870	12868	12937	13070	13242	13362	13458
13343	13383	13370	13325	13258	13173	13117	13076	13113	13181	13261	13357	13421
13162	13259	13306	13331	13321	13294	13267	13251	13233	13251	13290	13356	13414
13053	13112	13173	13232	13264	13290	13302	13302	13294	13286	13284	13310	13344
13094	13157	13226	13309	13378	13431	13469	13492	13500	13486	13472	13476	13486
13108	13091	13142	13220	13332	13420	13499	13546	13569	13571	13547	13511	13492
13149	13071	13073	13173	13290	13418	13524	13605	13672	13706	13681	13640	13590
13286	13171	13108	13166	13276	13398	13529	13658	13773	13812	13786	13725	13629
13377	13229	13102	13061	13136	13306	13459	13600	13720	13806	13789	13710	13633
13333	13143	12960	12894	12935	13115	13297	13466	13629	13745	13827	13794	13713
13514	13361	13200	13048	13027	13160	13330	13518	13698	13886	14005	14007	13888
13723	13540	13363	13227	13155	13245	13363	13517	13689	13912	14060	14084	14013
14006	13788	13590	13443	13337	13327	13440	13606	13785	13949	14093	14190	14172
14078	13932	13730	13504	13363	13282	13330	13462	13632	13873	14034	14125	14128
14085	14015	13880	13691	13506	13410	13401	13511	13662	13866	14031	14136	14168
14131	14110	14042	13955	13824	13680	13635	13680	13792	13944	14080	14179	14258
14149	14172	14169	14117	14040	13979	13921	13889	13930	14002	14099	14183	14249
14024	14086	14118	14125	14099	14053	14014	13995	13995	14029	14082	14153	14214
13918	13994	14075	14116	14135	14136	14135	14127	14122	14116	14134	14185	14234
13898	13955	14035	14120	14195	14266	14305	14315	14285	14235	14195	14160	14164
13497	13504	13595	13744	13875	13978	14070	14135	14143	14126	14095	14056	14022
13645	13572	13580	13693	13840	14003	14160	14310	14406	14429	14404	14323	14269
14058	13922	13857	13891	14000	14177	14376	14587	14691	14730	14729	14661	14548
14106	13929	13819	13777	13853	14013	14227	14485	14686	14773	14777	14715	14625
14462	14186	13991	13909	13915	14013	14181	14435	14659	14776	14825	14796	14713
14686	14474	14241	14079	14023	14073	14234	14463	14651	14789	14875	14871	14787
14723	14569	14366	14146	14026	14021	14118	14309	14546	14715	14833	14885	14858
14788	14687	14538	14367	14223	14146	14197	14338	14497	14683	14815	14894	14895
14896	14845	14750	14619	14496	14398	14406	14487	14604	14715	14834	14919	14946

Unit in 0.1 mm

March, 1960

Hour(UT) Day	0	1	2	3	4	5	6	7	8	9	10
1	14901	14809	14710	14604	14485	14418	14429	14527	14637	14738	14827
2	14980	14907	14819	14730	14637	14538	14505	14548	14626	14707	14792
3	14914	14880	14807	14726	14622	14550	14501	14477	14520	14607	14702
4	15067	15074	15042	14971	14893	14803	14736	14688	14676	14697	14737
5	15098	15159	15164	15116	15043	14964	14885	14809	14749	14698	14690
6	15146	15175	15210	15232	15212	15167	15067	14966	14848	14767	14707
7	15054	15067	15106	15156	15217	15242	15212	15143	15063	14997	14921
8	15215	15251	15307	15372	15452	15539	15541	15477	15376	15220	15071
9	15311	15286	15326	15387	15456	15526	15565	15549	15481	15334	15156
10	15306	15252	15289	15367	15464	15559	15625	15649	15630	15539	15398
11	15408	15324	15302	15347	15440	15546	15649	15704	15703	15658	15557
12	15453	15334	15257	15290	15380	15497	15611	15708	15782	15766	15644
13	15490	15356	15186	15118	15182	15321	15465	15606	15729	15762	15702
14	15593	15461	15341	15270	15249	15322	15470	15628	15771	15881	15911
15	15797	15641	15522	15425	15360	15378	15470	15632	15827	15963	16027
16	15931	15754	15567	15380	15272	15238	15286	15384	15545	15743	15905
17	16000	15903	15743	15558	15416	15355	15339	15388	15481	15639	15808
18	16062	16012	15902	15769	15596	15470	15419	15401	15433	15509	15613
19	16020	16021	15979	15888	15771	15651	15536	15466	15430	15456	15522
20	16078	16101	16110	16086	16018	15933	15820	15714	15620	15572	15573
21	16103	16149	16190	16192	16160	16083	15962	15842	15702	15584	15507
22	15889	15915	15974	16045	16094	16124	16117	16032	15914	15776	15643
23	16000	15986	16049	16142	16252	16323	16349	16316	16240	16105	15944
24	15938	15875	15895	16005	16108	16208	16285	16306	16266	16167	16047
25	16073	15986	15944	15964	16093	16248	16375	16484	16534	16463	16344
26	16272	16162	16102	16092	16148	16250	16375	16522	16645	16658	16574
27	16196	16005	15883	15813	15874	15999	16167	16364	16503	16558	16524
28	16230	16043	15901	15837	15874	15993	16150	16328	16524	16659	16692
29	16469	16250	16089	15974	15930	15993	16124	16292	16481	16652	16712
30	16626	16473	16283	16136	16086	16078	16137	16278	16472	16637	16713
31	16723	16613	16442	16270	16166	16109	16129	16201	16317	16437	16542

Station : Kyoto (II)

11	12	13	14	15	16	17	18	19	20	21	22	23
14896	14872	14798	14713	14629	14557	14516	14547	14627	14737	14844	14939	14988
14845	14864	14855	14806	14760	14701	14665	14675	14707	14743	14797	14846	14896
14793	14859	14882	14873	14850	14814	14780	14773	14796	14853	14913	14974	15034
14793	14842	14896	14954	14982	14973	14958	14946	14951	14963	14986	15016	15048
14725	14788	14865	14956	15027	15084	15113	15121	15106	15087	15081	15096	15117
14719	14767	14827	14915	15004	15104	15188	15233	15236	15197	15148	15099	15067
14874	14877	14923	15013	15110	15207	15302	15369	15403	15381	15336	15284	15232
14971	14901	14901	14969	15137	15311	15457	15563	15609	15607	15571	15491	15397
14990	14887	14852	14885	14998	15177	15385	15531	15595	15621	15592	15527	15428
15208	15038	14934	14919	14998	15205	15400	15573	15679	15729	15696	15622	15528
15377	15173	15016	14937	14932	15068	15291	15498	15624	15700	15703	15644	15560
15505	15336	15167	15041	15013	15094	15272	15461	15615	15716	15761	15726	15618
15616	15464	15287	15132	15046	15071	15196	15406	15573	15716	15810	15799	15712
15839	15686	15555	15429	15300	15239	15322	15474	15631	15785	15928	16027	15952
16031	15961	15781	15563	15442	15384	15391	15472	15599	15789	15967	16044	16024
15975	15930	15847	15721	15570	15476	15436	15487	15613	15766	15921	16013	16047
15925	15998	15999	15943	15851	15778	15728	15709	15743	15819	15918	16018	16059
15751	15877	15937	15946	15908	15846	15787	15756	15748	15793	15848	15922	15981
15620	15720	15825	15904	15965	15991	15992	15981	15961	15934	15942	15978	16030
15637	15752	15880	16003	16106	16172	16214	16230	16202	16163	16125	16091	16081
15480	15503	15592	15742	15884	16036	16119	16163	16144	16092	16034	15973	15913
15538	15503	15533	15639	15803	16000	16156	16254	16289	16259	16206	16130	16059
15786	15682	15665	15761	15914	16070	16223	16335	16405	16375	16294	16196	16056
15874	15725	15630	15638	15736	15903	16080	16244	16370	16436	16396	16305	16198
16194	16039	15923	15873	15943	16076	16223	16397	16567	16703	16735	16646	16445
16403	16182	16033	15921	15870	15943	16084	16282	16474	16600	16628	16552	16402
16409	16191	16013	15883	15823	15860	15973	16131	16315	16481	16563	16548	16422
16617	16493	16329	16166	16051	16040	16094	16225	16414	16570	16674	16675	16614
16703	16634	16502	16369	16271	16222	16241	16339	16481	16642	16733	16757	16721
16742	16729	16656	16534	16421	16354	16357	16429	16532	16646	16740	16785	16782
16628	16647	16614	16564	16513	16457	16413	16427	16499	16588	16678	16720	16697

Unit in 0.1 mm

Gravity

April, 1960

Hour(UT) / Day	0	1	2	3	4	5	6	7	8	9	10
1	16638	16548	16427	16291	16159	16060	16004	16037	16113	16228	16370
2	16628	16588	16503	16395	16296	16221	16190	16201	16231	16261	16301
3	16543	16548	16513	16475	16432	16379	16328	16302	16309	16359	16443
4	16938	16961	16975	16983	16965	16925	16875	16829	16802	16776	16789
5	17279	17295	17328	17357	17373	17349	17274	17171	17059	16969	16916
6	17141	17168	17235	17299	17357	17393	17396	17340	17191	17014	16869
7	16698	16708	16747	16802	16887	16951	16989	16965	16867	16741	16604
8	16635	16616	16676	16786	16935	17072	17166	17205	17198	17116	16936
9	16635	16541	16557	16646	16779	16965	17113	17214	17230	17161	17029
10	16736	16581	16536	16617	16772	16936	17103	17217	17292	17288	17189
11	16718	16498	16387	16401	16498	16714	16923	17100	17202	17237	17188
12	16917	16698	16522	16429	16457	16617	16859	17056	17200	17342	17385
13	17082	16909	16745	16600	16581	16672	16845	17028	17196	17352	17483
14	17255	17068	16888	16693	16575	16564	16640	16797	16991	17157	17312
15	17392	17234	17067	16912	16789	16719	16746	16838	16956	17102	17255
16	17564	17446	17273	17108	16918	16786	16724	16733	16809	16921	17055
17	17464	17445	17367	17259	17135	17017	16891	16851	16856	16929	17049
18	17352	17377	17375	17344	17273	17167	17050	16953	16897	16871	16889
19	17359	17409	17459	17505	17509	17466	17401	17322	17236	17159	17109
20	17535	17562	17614	17688	17741	17731	17667	17566	17457	17343	17229
21	17304	17320	17379	17468	17566	17647	17663	17639	17587	17487	17379
22	17256	17227	17286	17378	17510	17632	17738	17751	17706	17623	17513
23	17266	17185	17176	17285	17437	17564	17681	17792	17817	17768	17647
24	17316	17177	17128	17208	17336	17505	17651	17788	17909	17901	17789
25	17488	17338	17244	17244	17328	17471	17647	17847	18027	18064	18007
26	17544	17407	17288	17242	17281	17413	17558	17726	17889	18086	18108
27	17786	17596	17388	17318	17308	17410	17551	17734	17930	18079	18141
28	17860	17646	17460	17350	17300	17330	17465	17645	17843	17990	18070
29	17983	17844	17662	17515	17445	17435	17516	17655	17830	17992	18096
30	18054	17947	17806	17679	17583	17533	17533	17623	17774	17953	18087
31											

Station : Kyoto (II)

11	12	13	14	15	16	17	18	19	20	21	22	23
16509	16578	16585	16535	16488	16446	16413	16428	16466	16515	16564	16600	16631
16340	16369	16405	16430	16414	16380	16351	16343	16345	16363	16399	16442	16490
16543	16645	16723	16793	16848	16879	16883	16878	16870	16873	16882	16898	16918
16849	16941	17059	17172	17265	17338	17387	17406	17384	17351	17326	17296	17278
16919	16972	17042	17157	17266	17365	17434	17446	17407	17359	17296	17237	17178
16777	16742	16772	16836	16914	17018	17128	17166	17120	17040	16941	16842	16751
16489	16413	16437	16535	16663	16796	16917	17026	17065	17012	16918	16817	16715
16757	16619	16565	16581	16665	16836	17013	17140	17200	17186	17091	16956	16786
16865	16680	16560	16540	16639	16787	16949	17087	17188	17207	17149	17036	16896
17063	16916	16747	16675	16668	16733	16856	17038	17150	17186	17169	17077	16937
17077	16957	16806	16698	16657	16714	16857	17013	17180	17284	17299	17235	17096
17297	17152	17039	16923	16851	16869	16957	17087	17220	17360	17449	17400	17270
17517	17425	17309	17187	17104	17072	17102	17175	17314	17463	17561	17559	17442
17388	17394	17311	17202	17101	17056	17046	17090	17162	17288	17417	17487	17490
17376	17474	17506	17459	17365	17279	17238	17246	17297	17393	17491	17557	17595
17185	17299	17392	17428	17420	17388	17349	17298	17270	17282	17321	17388	17435
17186	17317	17422	17497	17529	17524	17488	17426	17354	17291	17271	17278	17316
16948	17066	17219	17355	17442	17499	17528	17518	17462	17380	17321	17299	17325
17110	17184	17315	17444	17557	17663	17746	17774	17735	17672	17617	17565	17534
17150	17137	17212	17327	17458	17575	17663	17707	17690	17628	17535	17416	17335
17248	17162	17168	17271	17400	17547	17658	17755	17772	17707	17604	17484	17348
17405	17296	17259	17308	17396	17508	17630	17735	17772	17745	17652	17540	17395
17518	17400	17322	17313	17367	17467	17577	17697	17792	17829	17738	17617	17477
17667	17543	17449	17407	17431	17525	17648	17818	17964	18028	17963	17820	17640
17873	17719	17614	17550	17520	17551	17649	17782	17941	18034	18004	17895	17720
18058	17919	17779	17674	17625	17654	17748	17897	18019	18114	18141	18094	17988
18139	18075	17974	17879	17783	17757	17810	17893	18000	18081	18120	18100	18016
18096	18072	18001	17915	17835	17796	17823	17894	17968	18041	18090	18097	18065
18146	18160	18130	18075	18008	17949	17927	17953	18004	18056	18105	18124	18111
18156	18194	18193	18166	18134	18095	18064	18068	18100	18140	18178	18210	18216

Unit in 0.1 mm

May, 1960

Day \ Hour(UT)	0	1	2	3	4	5	6	7	8	9	10
1	18182	18118	18028	17922	17814	17735	17703	17754	17843	17950	18042
2	18223	18204	18163	18096	18003	17916	17864	17839	17853	17902	17993
3	18175	18185	18169	18118	18054	18001	17941	17889	17866	17888	17941
4	18183	18205	18224	18223	18204	18170	18120	18065	18005	17965	17975
5	18129	18158	18205	18255	18270	18275	18247	18204	18142	18085	18035
6	18094	18127	18199	18274	18337	18389	18415	18376	18288	18197	18130
7	18009	18012	18086	18192	18304	18405	18474	18487	18437	18334	18224
8	17986	17928	17981	18118	18269	18414	18537	18612	18610	18547	18430
9	18046	17910	17927	18048	18207	18391	18546	18700	18764	18747	18637
10	18198	18020	17906	17930	18070	18271	18463	18646	18786	18861	18814
11	18170	17949	17799	17750	17849	18041	18272	18473	18670	18842	18870
12	18399	18202	17988	17859	17864	17959	18175	18389	18579	18783	18946
13	18590	18400	18220	18071	17960	17982	18120	18297	18477	18689	18865
14	18787	18612	18419	18242	18119	18047	18104	18281	18498	18716	18907
15	18441	18302	18117	17907	17732	17568	17432	17401	17448	17582	17770
16	17809	17759	17645	17527	17388	17253	17142	17061	17049	17174	17353
17	18426	18475	18506	18505	18470	18417	18361	18301	18256	18287	18360
18	18888	18944	18988	19000	18988	18961	18931	18891	18846	18810	18789
19	18932	18984	19081	19175	19253	19272	19233	19154	19077	19002	18941
20	18941	18982	19083	19212	19324	19405	19431	19405	19344	19262	19162
21	18915	18924	19032	19192	19313	19440	19502	19521	19487	19421	19321
22	18893	18852	18891	19049	19207	19380	19510	19589	19608	19561	19480
23	18956	18838	18821	18919	19080	19288	19463	19562	19622	19637	19575
24	19150	18969	18882	18902	19079	19282	19449	19580	19690	19735	19702
25	19285	19105	18992	18951	19010	19176	19390	19572	19700	19787	19789
26	19421	19257	19130	19047	19062	19169	19332	19497	19672	19824	19897
27	19546	19406	19252	19105	19089	19185	19318	19478	19628	19798	19939
28	19665	19523	19412	19305	19219	19215	19326	19521	19725	19900	20047
29	19949	19799	19614	19457	19353	19321	19356	19446	19602	19786	19933
30	19945	19831	19697	19540	19435	19378	19377	19439	19564	19747	19915
31	20028	19991	19911	19806	19685	19596	19532	19514	19591	19714	19837

Station : Kyoto (II)

11	12	13	14	15	16	17	18	19	20	21	22	23
18120	18188	18227	18237	18218	18191	18168	18135	18133	18165	18193	18221	18233
18078	18153	18204	18241	18248	18241	18203	18178	18145	18133	18124	18143	18157
18006	18088	18163	18237	18283	18305	18303	18278	18246	18203	18163	18158	18165
18015	18078	18157	18246	18342	18406	18415	18375	18320	18262	18199	18155	18131
18015	18051	18125	18216	18314	18415	18466	18453	18407	18345	18256	18155	18096
18090	18085	18136	18215	18312	18464	18575	18635	18583	18453	18315	18187	18083
18106	18047	18072	18167	18280	18402	18508	18570	18560	18495	18396	18245	18096
18308	18204	18152	18189	18309	18454	18560	18653	18689	18637	18527	18388	18234
18500	18387	18317	18298	18344	18447	18626	18800	18944	18917	18778	18597	18382
18654	18510	18405	18336	18351	18406	18509	18619	18763	18823	18773	18623	18420
18813	18672	18519	18400	18358	18370	18459	18578	18759	18855	18851	18746	18561
18973	18895	18779	18639	18519	18492	18521	18621	18763	18878	18939	18910	18782
18976	18986	18938	18807	18669	18603	18595	18653	18763	18878	18958	18988	18929
19026	19071	19043	18962	18840	18724	18616	18521	18509	18536	18562	18578	18536
17962	18073	18121	18096	18020	17912	17792	17706	17649	17648	17707	17758	17799
17572	17775	17915	18014	18097	18139	18139	18126	18128	18150	18205	18287	18373
18466	18633	18763	18870	18935	18977	18974	18942	18895	18843	18790	18784	18827
18803	18902	19050	19190	19312	19379	19373	19344	19290	19212	19111	19002	18916
18939	18985	19090	19222	19349	19453	19494	19487	19448	19353	19227	19086	18991
19081	19073	19113	19211	19344	19460	19527	19543	19499	19411	19297	19149	19008
19197	19119	19102	19175	19296	19419	19508	19566	19555	19485	19359	19202	19031
19390	19288	19224	19264	19340	19437	19513	19571	19604	19556	19460	19316	19138
19502	19420	19345	19343	19385	19462	19546	19633	19682	19669	19596	19486	19337
19616	19529	19441	19400	19401	19472	19552	19642	19723	19754	19719	19606	19450
19737	19641	19535	19468	19457	19486	19559	19653	19738	19793	19783	19686	19559
19857	19761	19645	19554	19509	19528	19584	19660	19767	19847	19887	19826	19687
19998	19962	19847	19738	19667	19637	19653	19707	19795	19906	19980	19944	19807
20107	20110	20083	20017	19945	19896	19896	19936	20011	20076	20105	20097	20036
20008	20037	20024	19967	19897	19826	19777	19775	19797	19866	19957	20016	19996
20009	20076	20091	20078	20039	20003	19976	19961	19965	19984	20006	20029	20036
19948	20036	20082	20097	20089	20058	20000	19957	19940	19937	19951	19988	20019

Unit in 0.1 mm

Gravity

June, 1960

Hour(UT) / Day	0	1	2	3	4	5	6	7	8	9	10
1	20049	20050	20020	19953	19869	19791	19711	19669	19676	19733	19859
2	19998	20015	20029	20012	19973	19909	19839	19787	19768	19803	19861
3	19992	20043	20083	20124	20142	20143	20121	20073	20011	19965	19946
4	19978	20004	20065	20145	20197	20220	20211	20177	20123	20059	19998
5	19807	19851	19946	20056	20176	20272	20315	20319	20280	20206	20129
6	19735	19744	19849	19996	20125	20275	20407	20467	20449	20366	20275
7	19753	19670	19714	19875	20036	20191	20326	20475	20557	20512	20398
8	19904	19794	19762	19827	20007	20205	20400	20630	20842	20911	20829
9	20215	20029	19900	19881	20010	20211	20392	20604	20812	20949	20989
10	20446	20242	20029	19918	19962	20100	20315	20512	20711	20908	21062
11	20642	20435	20241	20075	20002	20042	20197	20386	20633	20826	20944
12	20825	20673	20466	20272	20131	20072	20127	20268	20455	20683	20823
13	20950	20852	20731	20585	20417	20298	20284	20363	20482	20674	20830
14	20989	20952	20882	20792	20682	20578	20511	20514	20563	20670	20782
15	21031	21035	21013	20971	20904	20837	20776	20747	20777	20833	20897
16	20974	21004	21040	21058	21037	20992	20922	20867	20828	20827	20870
17	20840	20888	20949	21015	21047	21047	21011	20980	20935	20903	20885
18	20741	20793	20846	20917	20978	21047	21093	21103	21068	21016	20973
19	20754	20788	20862	20945	21056	21185	21292	21328	21329	21275	21193
20	20782	20763	20793	20876	21012	21182	21368	21515	21517	21470	21414
21	20899	20837	20848	20966	21135	21305	21466	21570	21630	21643	21598
22	20959	20818	20765	20807	20951	21164	21356	21502	21593	21602	21564
23	21067	20881	20813	20821	20893	21045	21246	21437	21569	21637	21611
24	21199	20982	20845	20789	20833	20987	21182	21372	21579	21697	21737
25	21238	21044	20859	20758	20762	20851	21050	21244	21387	21495	21574
26	21356	21213	21044	20883	20828	20873	21035	21206	21376	21504	21587
27	21459	21351	21226	21087	20987	20963	21054	21210	21362	21491	21600
28	21418	21292	21159	21012	20828	20722	20717	20800	20937	21071	21177
29	21357	21308	21245	21164	21079	20998	20986	21053	21185	21308	21445
30	21630	21633	21596	21533	21465	21402	21349	21308	21339	21404	21487
31											

Station : Kyoto (II)

11	12	13	14	15	16	17	18	19	20	21	22	23
19959	20047	20117	20151	20169	20152	20125	20078	20029	19989	19958	19959	19972
19944	20028	20106	20177	20210	20218	20187	20136	20084	20015	19971	19956	19961
19977	20048	20141	20221	20301	20349	20356	20303	20232	20147	20074	20017	19986
19990	20018	20070	20156	20234	20306	20356	20335	20265	20155	20045	19939	19834
20065	20036	20065	20138	20234	20324	20397	20415	20340	20235	20122	19975	19842
20195	20126	20105	20134	20220	20345	20465	20538	20498	20395	20229	20087	19916
20295	20209	20165	20175	20234	20344	20474	20616	20677	20552	20378	20208	20058
20690	20517	20430	20403	20432	20522	20681	20857	20944	20939	20840	20641	20410
20888	20748	20639	20570	20557	20589	20650	20767	20881	20976	20949	20810	20637
21093	21008	20847	20686	20609	20600	20663	20779	20940	21079	21117	21041	20858
21008	21013	20964	20891	20813	20741	20721	20769	20824	20893	20950	20978	20924
20924	20972	20978	20938	20873	20806	20754	20753	20784	20853	20933	20983	20986
20933	21019	21062	21069	21043	21002	20950	20891	20857	20853	20899	20954	20986
20902	20988	21049	21079	21062	21022	20960	20899	20853	20863	20903	20951	21002
20983	21084	21178	21282	21317	21268	21182	21087	20996	20927	20886	20887	20927
20936	21009	21096	21187	21235	21213	21151	21076	20996	20924	20859	20812	20808
20896	20927	20977	21041	21127	21208	21207	21135	21040	20946	20849	20765	20723
20943	20953	20993	21051	21136	21266	21356	21334	21198	21053	20934	20853	20786
21104	21044	21070	21144	21244	21371	21453	21459	21397	21255	21093	20945	20848
21357	21313	21301	21335	21401	21481	21548	21588	21580	21528	21411	21265	21058
21529	21459	21404	21399	21444	21508	21579	21626	21641	21610	21513	21368	21183
21503	21418	21351	21318	21333	21394	21493	21563	21601	21582	21524	21410	21243
21545	21473	21417	21372	21365	21411	21467	21535	21603	21630	21610	21506	21377
21669	21562	21422	21357	21331	21346	21390	21450	21500	21529	21530	21473	21380
21579	21523	21456	21390	21350	21350	21381	21439	21504	21563	21579	21550	21460
21623	21609	21530	21437	21377	21358	21386	21427	21487	21550	21605	21598	21545
21674	21686	21638	21552	21469	21406	21378	21392	21446	21483	21519	21527	21497
21250	21289	21287	21239	21191	21150	21121	21129	21186	21251	21309	21350	21368
21553	21655	21703	21673	21615	21551	21505	21470	21467	21491	21518	21559	21598
21585	21700	21771	21812	21778	21695	21577	21490	21429	21423	21450	21498	21554

Unit in 0.1 mm

July, 1960

Hour(UT) Day	0	1	2	3	4	5	6	7	8	9	10
1	21616	21659	21669	21625	21567	21503	21450	21404	21400	21440	21515
2	21615	21675	21748	21788	21781	21726	21663	21594	21544	21523	21574
3	21435	21545	21673	21762	21829	21848	21833	21794	21753	21700	21671
4	21344	21429	21563	21731	21889	21949	21959	21940	21904	21863	21827
5	21250	21291	21409	21587	21802	21936	22008	22044	22050	22015	21965
6	21316	21278	21340	21518	21696	21905	22052	22174	22252	22243	22149
7	21486	21355	21325	21419	21580	21804	22036	22215	22325	22379	22347
8	21726	21519	21372	21344	21409	21663	21897	22117	22355	22506	22515
9	21937	21715	21517	21408	21455	21585	21822	22105	22336	22494	22557
10	22207	21994	21739	21587	21536	21587	21725	21992	22217	22385	22502
11	22324	22184	22034	21852	21692	21672	21810	21996	22189	22336	22442
12	22420	22338	22210	22073	21909	21807	21827	21934	22115	22280	22398
13	22423	22388	22327	22241	22143	22038	21990	22023	22125	22243	22348
14	22423	22445	22431	22389	22325	22268	22228	22227	22249	22311	22404
15	22380	22424	22462	22469	22437	22390	22349	22307	22269	22252	22288
16	22344	22415	22454	22417	22343	22275	22255	22275	22315	22354	22399
17	21984	22053	22160	22285	22376	22436	22464	22464	22436	22386	23346
18	21956	22019	22127	22246	22368	22476	22556	22586	22559	22501	22455
19	21964	21966	22081	22239	22394	22515	22612	22671	22695	22654	22584
20	22066	22037	22073	22172	22347	22510	22620	22687	22718	22707	22648
21	22109	22011	22005	22127	22293	22475	22607	22715	22778	22775	22730
22	22273	22121	22032	22051	22184	22391	22589	22757	22871	22951	22916
23	22376	22232	22140	22148	22276	22439	22586	22744	22911	23023	23073
24	22713	22562	22449	22378	22398	22528	22702	22858	23004	23123	23187
25	22827	22675	22548	22462	22434	22466	22592	22759	22944	23125	23319
26	23125	22957	22812	22705	22655	22654	22751	22928	23132	23311	23459
27	23319	23170	22999	22858	22762	22748	22788	22898	23059	23249	23385
28	23369	23281	23151	22993	22889	22836	22840	22920	23039	23190	23340
29	23331	23323	23235	23133	23032	22940	22845	22818	22925	23071	23210
30	23265	23327	23353	23345	23291	23195	23092	23024	23031	23095	23212
31	23191	23294	23381	23424	23424	23385	23334	23265	23226	23266	23351

Station : Kyoto (II)

11	12	13	14	15	16	17	18	19	20	21	22	23
21662	21807	21900	21940	21938	21904	21837	21763	21676	21593	21538	21540	21567
21651	21755	21853	21913	21953	21932	21877	21790	21682	21542	21433	21346	21351
21693	21774	21882	21954	22004	22030	22002	21923	21813	21683	21544	21412	21334
21816	21828	21863	21925	21999	22056	22063	22037	21952	21839	21669	21471	21314
21909	21867	21874	21923	21995	22068	22137	22138	22094	22009	21869	21681	21455
22059	21994	21961	21989	22054	22138	22211	22270	22262	22198	22059	21881	21682
22245	22110	22026	22031	22097	22177	22279	22388	22452	22421	22296	22133	21960
22408	22257	22148	22079	22065	22099	22184	22337	22504	22562	22504	22337	22137
22546	22466	22372	22276	22206	22189	22243	22335	22460	22573	22588	22520	22400
22545	22503	22418	22312	22223	22168	22167	22225	22305	22394	22457	22485	22445
22540	22565	22497	22400	22318	22244	22209	22220	22271	22343	22419	22471	22482
22501	22570	22559	22482	22381	22305	22239	22201	22198	22241	22309	22373	22421
22433	22500	22544	22515	22448	22354	22287	22237	22216	22228	22261	22311	22370
22515	22630	22700	22711	22667	22559	22452	22360	22298	22255	22254	22283	22330
22346	22407	22482	22551	22600	22613	22555	22439	22327	22241	22201	22230	22278
22438	22478	22520	22557	22585	22573	22524	22436	22333	22206	22075	21978	21956
22343	22388	22442	22493	22536	22566	22571	22536	22464	22338	22186	22052	21966
22433	22442	22484	22522	22566	22599	22621	22615	22546	22448	22316	22176	22037
22532	22497	22503	22526	22562	22613	22665	22686	22663	22596	22496	22353	22180
22587	22538	22514	22519	22559	22620	22675	22708	22707	22656	22557	22417	22258
22662	22598	22540	22520	22537	22588	22681	22769	22821	22798	22720	22580	22430
22811	22714	22624	22569	22565	22625	22705	22790	22878	22898	22864	22751	22585
23026	22926	22848	22791	22750	22769	22850	22939	23010	23053	23046	22974	22859
23192	23118	23010	22900	22839	22809	22810	22852	22944	23060	23119	23079	22968
23400	23351	23251	23145	23064	23001	23003	23061	23128	23226	23306	23324	23257
23496	23449	23349	23227	23128	23039	23019	23076	23175	23282	23380	23427	23408
23440	23436	23372	23280	23169	23072	23024	23055	23122	23212	23301	23375	23405
23441	23480	23450	23381	23281	23160	23061	22993	22989	23040	23115	23193	23270
23340	23435	23474	23462	23381	23274	23125	23022	23000	23025	23071	23122	23195
23313	23397	23454	23484	23462	23384	23265	23148	23045	22968	22924	22983	23083
23433	23502	23546	23574	23549	23494	23414	23304	23154	23035	22949	22911	22953

Unit in 0.1 mm

August, 1960

Hour(UT) Day	0	1	2	3	4	5	6	7	8	9	10
1	23030	23146	23259	23384	23483	23529	23500	23461	23425	23406	23425
2	22922	23026	23174	23325	23462	23545	23576	23575	23538	23468	23400
3	22764	22804	22923	23131	23360	23527	23595	23575	23520	23453	23386
4	22858	22854	22931	23095	23301	23500	23636	23722	23750	23709	23630
5	22866	22804	22807	22883	23005	23262	23502	23666	23798	23807	23741
6	23120	22921	22844	22866	22986	23156	23351	23526	23659	23698	23645
7	23244	23065	22936	22912	22965	23096	23243	23444	23646	23760	23785
8	23545	23394	23230	23107	23079	23179	23356	23556	23734	23890	24003
9	23724	23587	23450	23297	23219	23228	23325	23494	23651	23809	23968
10	23911	23770	23632	23521	23463	23458	23491	23587	23703	23865	24035
11	24046	24012	23877	23760	23673	23617	23587	23599	23663	23795	23968
12	23928	23957	23888	23798	23731	23688	23674	23689	23733	23826	23950
13	23857	23910	23955	23957	23898	23844	23814	23835	23872	23926	23981
14	23775	23847	23900	23934	23943	23919	23886	23846	23831	23829	23840
15	23349	23416	23494	23565	23630	23676	23683	23654	23602	23554	23514
16	23516	23592	23668	23752	23842	23938	24021	24059	24057	24009	23949
17	23286	23289	23375	23483	23619	23764	23911	24031	24122	24177	24210
18											
19											
20											
21											
22											
23											
24											
25											
26											
27											
28											
29											
30											
31											

Station : Kyoto (II)

11	12	13	14	15	16	17	18	19	20	21	22	23
23463	23499	23534	23562	23580	23574	23524	23450	23335	23175	22992	22884	22854
23365	23375	23416	23464	23522	23565	23574	23504	23774	23223	23084	22945	22817
23351	23366	23429	23511	23585	23651	23685	23686	23635	23539	23384	23155	22951
23549	23464	23442	23486	23555	23623	23703	23748	23714	23626	23514	23303	23052
23662	23583	23523	23483	23494	23576	23676	23773	23800	23745	23663	23539	23337
23549	23463	23393	23337	23333	23401	23498	23599	23693	23733	23665	23551	23395
23717	23627	23548	23485	23449	23454	23507	23603	23701	23807	23839	23781	23668
23989	23849	23693	23594	23538	23495	23503	23589	23709	23837	23938	23967	23860
23996	23938	23787	23667	23581	23529	23510	23554	23644	23738	23838	23947	23978
24132	24119	24021	23868	23755	23672	23616	23612	23659	23740	23826	23918	24016
24104	24140	24085	23948	23793	23687	23607	23547	23558	23608	23679	23758	23841
24069	24147	24181	24137	24048	23938	23829	23729	23664	23637	23668	23729	23789
24030	24067	24086	24084	24049	23976	23882	23791	23695	23626	23599	23635	23698
23872	23901	23925	23921	23886	23813	23717	23598	23477	23395	23325	23281	23296
23521	23553	23591	23640	23687	23709	23718	23699	23649	23595	23543	23507	23487
23891	23847	23829	23877	23961	23980	23918	23829	23721	23635	23545	23450	23357
24226	24269	24320	24373	24455	24573	24698	24747	24712	24585	24420	24304	24227

Unit in 0.1 mm