19. COMMISSION DE LA VARIATION DES LATITUDES

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A. Report of the Director of the Central Bureau

In consequence of the decision made by the Fifth General Assembly of the I.A.U. I have been entrusted, from January 1936, with the direction of the Central Bureau for the International Service of Latitudes.

I am much indebted to Prof. Kimura, who preceded me as Director and to Prof. Kohlschütter, Director of the Geodetic Institute of Potsdam, for information and advice, which has been of great assistance to me; therefore I desire to acknowledge to them my deep gratitude.

A preliminary discussion of the results obtained from the observations of 1936 appeared in the *Astronomische Nachrichten*, **263**, No. 6290; I am preparing another report containing the results of the observations of 1937, which will be printed before the next Assembly. Owing to the late arrival of the observations of one or two stations (e.g. those of November 1937 from Adelaide, which arrived on April 3, were not sent until March 4, that is, three months after completing the observations), the calculation of the results of all stations has only been possible after considerable delay.

During the last two years the eight stations have continued regular observations and no unusual event has troubled the normal course of the observations. No alteration has been made either in the instruments, or in the programme, or in the methods of observation; but at Carloforte there have been some changes in the staff. I feel it to be my duty, and I am certain that I interpret the feelings of all the members of the Commission, to thank the observers at the eight stations for their assiduous, diligent and conscientious co-operation. At the same time I want to ask them to follow as closely as possible in their observations the precise instructions given forty years ago by Prof. Th. Albrecht in his booklet: *Anleitung zum Gebrauche des Zenitteleskops*. Most, but not all, of the observers follow these directions; consequently we have to note errors caused by insufficient care being taken in regulating the levels, by too great an inclination of the micrometer threads, or to the careless adjustment of the instrument. Perhaps Albrecht's book is not known to all observers, and I admit that some parts of it could or should be slightly modified, and that the language in which it is written may cause some difficulty. I think, however, that it should not be difficult to have a new edition in English, published at the expense and under the auspices of our Commission.

The pairs of stars observed in the two years amount to 24,311, viz. 11,809 in 1936, and 12,502 in 1937. The calculations have been made assuming:

I. As position and proper motion of stars those established by Prof. Kimura;

II. As instrumental constants the values shown in Table I.

The apparent places of the stars were calculated using the constants of the *Berliner Jahrbuch*, kindly sent us in advance by Prof. Kopff, and including also the short period nutation terms. At the date of this report the ephemerides for 1939 were almost ready. For the instrumental constants we have taken as basis the values communicated to us by Prof. Kimura in 1935, taking into account only a few new data of later observation. We have not used the rich material of observations made in the last two years, and particularly at Batavia, La Plata, Mizusawa

TABLE I

Values of the instrumental constants adopted in the reductions

		Level I	Level II
Mizusawa	$R = 39''\cdot9393$	$P = 0^r\cdot02951$	$P = 0^r\cdot03378$
Kitab	·7580	·02435	·02264
Carloforte	·7372	·02534	·02447
Gaithersburg	·6354	·02544	·02611
Ukiah	·7528	·02862	·02657
Adelaide	·9401	·02454	·02334
La Plata	·7601	·02442	·02865

and Kitab, in order not to alter the homogeneity of the calculations and of the results. But we have now undertaken a new discussion of all the observations made in the last three years, which will give us the constants for the definitive calculation as well as more reliable values in future. The comparison of the different values which will be obtained for the screws of the micrometers from the observation of the circumpolar stars at their greatest digression, from the pairs of stars suggested by Prof. Kimura, and from the observations of latitude themselves, will be of particular interest.

In order not to introduce any discontinuity between the provisional results and those communicated in the past by Prof. Kimura, we have followed the identical procedure for the deduction of the polar co-ordinates, obtaining the following values when the observations at the northern stations only are used:

Polar path from northern stations only

	X	Y		X	Y
	″	″		″	″
1936·0	−0·10	+0·07	1937·0	−0·16	+0·06
·1	− ·13	+ ·08	·1	− ·17	+ ·09
·2	− ·12	+ ·05	·2	− ·15	+ ·13
·3	− ·08	+ ·05	·3	− ·09	+ ·15
·4	− ·01	+ ·07	·4	− ·01	+ ·15
·5	+ ·07	+ ·06	·5	+ ·08	+ ·11
·6	+ ·06	+ ·05	·6	+ ·10	+ ·04
·7	·00	+ ·02	·7	+ ·06	+ ·02
·8	− ·06	·00	·8	+ ·02	+ ·01
·9	− ·12	+ ·01	·9	− ·04	+ ·01
1937·0	− ·16	+ ·06	1938·0	(− ·16)	(− ·01)

The co-ordinates of the pole deduced by the same process, but taking into account also the results at the southern stations, Adelaide and La Plata, are somewhat different but are more regular. The values are as follows:

Polar path from northern and southern stations

	X	Y		X	Y
	″	″		″	″
1936·0	−0·11	+0·07	1937·0	−0·16	+0·04
·1	− ·12	+ ·09	·1	− ·18	+ ·07
·2	− ·09	+ ·10	·2	− ·13	+ ·13
·3	− ·04	+ ·10	·3	− ·06	+ ·15
·4	+ ·01	+ ·09	·4	+ ·01	+ ·16
·5	+ ·06	+ ·07	·5	+ ·08	+ ·13
·6	+ ·05	+ ·04	·6	+ ·09	+ ·06
·7	·00	·00	·7	+ ·04	+ ·02
·8	− ·05	− ·02	·8	− ·03	− ·02
·9	− ·10	− ·02	·9	− ·10	− ·03
1937·0	− ·16	+ ·04	1938·0	(− ·18)	(− ·02)

The regularity of the two different paths will be seen from the two figures; but the second one, based on the results of the seven stations, shows without doubt a greater regularity and superior accuracy.

As I pointed out in my first report, this seems to be due principally to the fact that the observations of some stations are rather scanty during the winter in the northern hemisphere, but at the same time there is a partial compensation in the southern observations, which then enjoy the best weather.

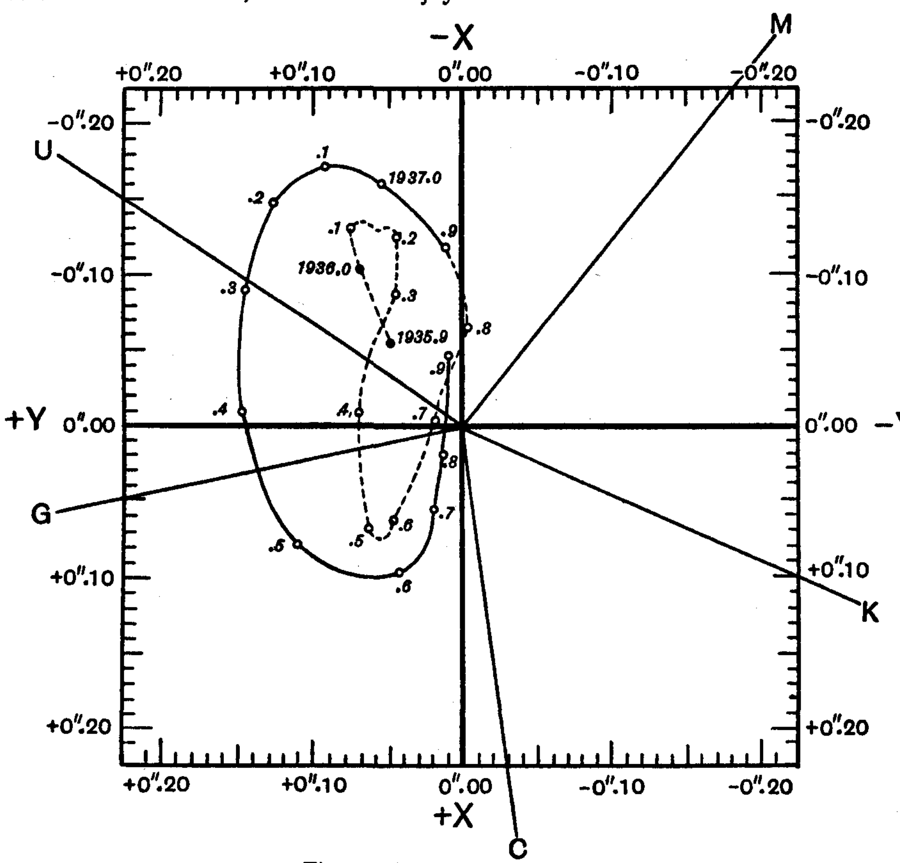

Fig. 1. Northern stations only.

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But this second reduction, although it leads to a more certain path of the pole, does not avoid the many anomalies which the observations of the different stations present. First of all, if we compare the constants of the terms which determine the variations of local character, deduced from the observations in the two successive years, not only do we find sensible differences according to whether they are

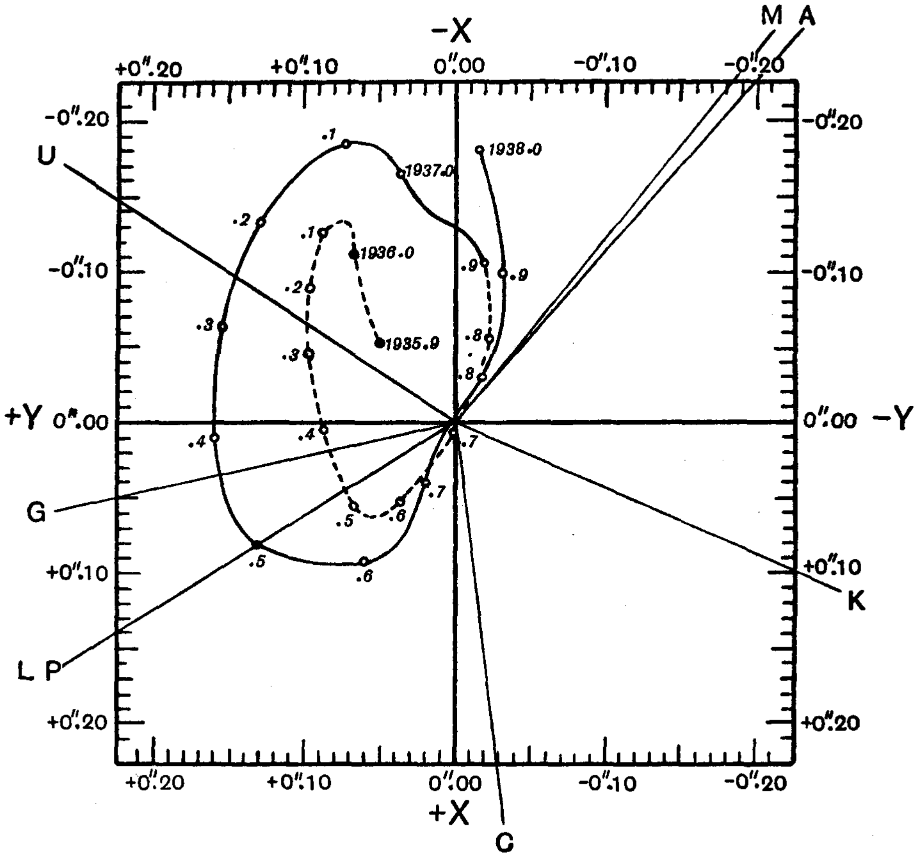

Fig. 2. Northern and Southern stations.

deduced from the northern stations only or from all the seven stations; but what seems still more remarkable is the considerable difference of values between the two successive years 1936 and 1937, as shown in the table on p. 133.

The first two columns give us the values of the average constant difference between the latitudes deduced from the evening and morning observations; the third and fifth columns contain the coefficient of the analytical expression of the periodical local variations depending on the variable parameter $(2\odot + A_2 - \alpha)$, where $\odot$ is the longitude of the Sun; the phase angles A_2 are given in the fourth and sixth columns.* The two series of values correspond respectively to the deductions made by

* Kimura assumes that there are local variations of latitude, of the form

$$a_1 \sin(\odot + A_1 - \alpha) + a_2 \sin(2\odot + A_2 - \alpha).$$

The first term gives rise, in the international programme, to a constant difference between evening and morning latitudes.

	1936	1937	1936		1937	
	″	″	″	°	″	°
Mizusawa	−0·034	−0·015	+0·065	+ 40	+0·053	+ 0
Kitab	− ·031	− ·006	+ ·080	+ 24	+ ·057	+ 38
Carloforte	− ·014	+ ·006	+ ·035	− 3	+ ·033	− 52
Gaithersburg	− ·030	− ·036	+ ·038	− 55	+ ·056	+ 31
Ukiah	− ·006	− ·010	+ ·030	− 63	+ ·023	+ 22
Mizusawa	− ·014	− ·019	+ ·021	−116	+ ·036	− 26
Kitab	+ ·003	− ·005	+ ·024	+ 10	+ ·043	− 21
Carloforte	+ ·004	+ ·010	+ ·034	− 38	+ ·037	− 50
Gaithersburg	− ·021	− ·033	+ ·012	− 80	+ ·063	− 22
Ukiah	− ·016	− ·010	+ ·015	− 44	+ ·022	+ 17
Adelaide	+ ·001	+ ·006	+ ·037	+ 12	+ ·041	−156
La Plata	·000	− ·002	+ ·026	− 81	+ ·015	− 69

using only the northern stations, or by using these in combination with the southern ones. This considerable diversity of results raises a natural doubt as to the reality of the terms. It may be observed here that the second reduction, i.e. the one based on the greater number of stations and which has the greater reliability, gives values for the different coefficients that are sensibly smaller than those given by the first reduction. This suggests that if it were possible to increase the order of precision of the results, those coefficients would tend to zero values. On the other hand, if we compare the values of the corrections required by the declinations, derived from the observations of the two separate years by the two distinct processes, the results of the evening observations appear evidently to be in better accordance with those of the morning observations when the observations from the southern stations are incorporated. Comparing again among themselves the values deduced in the two years, we remark also that the differences tend to be smallest in those months when we have the largest number of observations, and consequently the greatest accuracy (see Table II). Considering now that the number of pairs of stars observed, on which is based the determination of these values, varies from 370 to 840, we can as a rough approximation say that, on an average, for each value about 600 pairs are observed. If, therefore, we attribute to the observation of each pair a mean error not less than ±0″·30, the mean error to be attributed to the single values of the correction of declination will not be less than ±0·″013. Consequently the differences between the values of the two years will have a mean error of the order of ±0″·018. If to such value we add the portion due to the insufficient knowledge of the proper motions, we should certainly not be far from the ±0″·026 presented by those differences. From this it seems legitimate to conclude that the order of precision of the observations of a pair of stars is not very far from ±0″·30 and that, in consequence, it must be considered useless to try to fix quantitatively phenomena which imply latitude variations of the order of only a few hundredths of a second of arc. The International Stations were established about forty years ago to study the displacements of the pole, which were considered to be of the order of some tenths of a second, and the instruments were designed to this end. The results have been better than were foreseen, and have enabled new and more delicate problems to be investigated, involving motions of an order of magnitude that reach or slightly surpass the tenth part of those then taken into consideration. To increase the number of stations cannot be advisable, both because of the difficulty of organization and because of the expense, while on the other hand the benefit received would be limited by the insufficient means of research. It is not by means of telescopes of one metre focal distance that we can see the hundredths of a second of arc, and what is not seen cannot be measured! The zenithal telescopes of the International Stations have given all that could be expected from them, but if we want to study the phenomena which present themselves to-day and to enquire deeply into motions of local origin and into the motions of short period, it is necessary to consider the question of the introduction of new instruments, capable of giving an accuracy that the present zenith telescopes cannot give.

TABLE II*a*

Corrections to the mean declinations of the groups observed at the northern stations

1936–37 Group	From northern stations only: Evening ″	Morning ″	E.–M. ″	From all stations: Evening ″	Morning ″	E.–M. ″
IV	+0·103	—	—	+0·123	—	—
V	− ·096	−0·096	0·000	− ·096	−0·081	−0·015
VI	+ ·079	+ ·101	− ·022	+ ·059	+ ·103	− ·044
VII	+ ·012	+ ·052	− ·040	− ·012	+ ·042	− ·054
VIII	− ·083	− ·018	− ·065	− ·102	− ·050	− ·052
IX	− ·197	− ·170	− ·027	− ·212	− ·192	− ·020
X	− ·127	− ·060	− ·067	− ·129	− ·089	− ·040
XI	+ ·057	+ ·056	+ ·001	+ ·080	+ ·021	+ ·059
XII	+ ·049	+ ·110	− ·061	+ ·076	+ ·096	− ·020
I	+ ·113	+ ·141	− ·028	+ ·115	+ ·144	− ·029
II	− ·111	− ·091	− ·020	− ·082	− ·077	− ·005
III	+ ·124	+ ·185	− ·061	+ ·150	+ ·176	− ·026
IV	+ ·100	+ ·052	+ ·048	+ ·107	+ ·079	+ ·028
V	− ·126	− ·080	− ·046	− ·129	− ·075	− ·053
VI	+ ·029	+ ·046	− ·017	+ ·032	+ ·053	− ·021
VII	− ·018	− ·022	+ ·004	− ·014	− ·017	+ ·003
VIII	− ·091	− ·090	− ·001	− ·087	− ·086	− ·001
IX	− ·215	− ·193	− ·022	− ·214	− ·208	− ·006
X	− ·103	− ·112	+ ·009	− ·100	− ·110	+ ·010
XI	+ ·044	+ ·015	+ ·029	+ ·041	+ ·043	− ·002
XII	+ ·070	+ ·075	− ·005	+ ·070	+ ·071	− ·001
I	+ ·079	+ ·092	− ·013	+ ·090	+ ·097	− ·007
II	− ·131	− ·110	− ·021	− ·123	− ·109	− ·014
III	+ ·142	+ ·109	+ ·033	+ ·145	+ ·112	+ ·033
IV	—	+ ·019	—	—	− ·003	—

TABLE II*b*

Values of the corrections of the mean declinations of each group observed at the northern stations

Group	1936 ″	1937 ″	1936–37 ″	1936 ″	1937 ″	1936–37 ″
IV	+0·072	+0·076	−0·004	+0·101	+0·093	+0·008
V	− ·096	− ·103	+ ·007	− ·088	− ·102	+ ·014
VI	+ ·090	+ ·037	+ ·053	+ ·081	+ ·042	+ ·039
VII	+ ·032	− ·020	+ ·052	+ ·015	− ·015	+ ·030
VIII	− ·051	− ·090	+ ·039	− ·076	− ·086	+ ·010
IX	− ·183	− ·204	+ ·021	− ·202	− ·211	+ ·009
X	− ·093	− ·107	+ ·014	− ·109	− ·105	− ·004
XI	+ ·057	+ ·029	+ ·028	+ ·050	+ ·042	+ ·008
XII	+ ·079	+ ·072	+ ·007	+ ·086	+ ·071	+ ·015
I	+ ·127	+ ·085	+ ·042	+ ·129	+ ·093	+ ·036
II	− ·101	− ·120	+ ·019	− ·079	− ·116	+ ·037
III	+ ·154	+ ·125	+ ·029	+ ·163	+ ·128	+ ·035

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To determine stellar parallaxes with accuracy it has been necessary to adopt instruments with comparatively long focal distances; and just as it has been necessary to employ meridian circles, transit instruments, and vertical circles of more than two metres focal length, it will also be necessary to use more powerful instruments for latitude variation observations. But this alone may prove insufficient if the means are not found to avoid at the same time the inconveniences resulting from the levels and from the double system of axes (vertical and horizontal); it would be necessary to come back to the pattern experimented with some years ago at Gaithersburg, transforming the telescope from photographic to visual. With such a telescope rapid and accurate observation of stars in the zenith will be possible, while the increased dimensions of the objective will make possible the selection of suitable pairs of stars; the work involved in the development of photographic plates will be avoided; the errors of refraction will be reduced to a minimum; and the elimination of the axis of rotation (by turning the ensemble of the objective glass and the eyepiece in one plane) will make insignificant the errors that now arise from the levels. At the same time the doubled or tripled focal distance and the increased power of the eyepiece will permit a corresponding increase in the precision of the observations. I think that instead of a mean error of $\pm 0''\cdot 30$, we shall be able to reach easily $\pm 0''\cdot 10$, and consequently with groups formed of 8 or 9 pairs, it should be possible to determine the latitude in one evening or morning with an error of $\pm 0''\cdot 03$. Then, and perhaps only then, shall we be able to ascertain the real and effective existence of the supposed various polar motions and eventually to interpret their physical meaning.

In Table III are contained the values of instantaneous latitudes determined at Batavia, together with the numbers of pairs observed in each period. I did not

TABLE III

Values of latitudes observed at the Batavia station

Epoch	Group	No. of pairs	Lat.	Group	No. of pairs	Lat.
1936·06	IV	44	38″·301	V	42	38″·514
·14	V	48	·514	VI	79	·554
·22	VI	72	·579	VII	62	·822
·31	VII	44	·822	VIII	45	·860
·39	VIII	92	·912	IX	111	·708
·47	IX	66	·704	X	72	·242
·55	X	103	·127	XI	112	·408
·64	XI	100	·342	XII	103	·691
·72	XII	86	·580	I	112	·353
·81	I	84	·297	II	84	·278
·89	II	50	·232	III	53	·629
·97	III	36	·732	IV	48	·176
1937·06	IV	74	·216	V	71	·395
·14	V	72	·401	VI	81	·447
·22	VI	74	·547	VII	82	·754
·30	VII	85	·733	VIII	80	·834
·39	VIII	102	·893	IX	114	·720
·48	IX	83	·603	X	82	·139
·55	X	102	·110	XI	130	·401
·64	XI	89	·345	XII	100	·711
·72	XII	97	·568	I	98	·277
·81	I	99	·155	II	95	·177
·88	II	82	·161	III	81	·633
·97	III	42	·473	IV	67	·193

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think it necessary to combine these observations with those of the other stations, because it would involve the introduction of another unknown, viz. the residual correction to the declinations, and because of the additional uncertainty which would come from assuming for the mean latitude of Batavia a value which might correspond to a mean pole systematically different from that adopted for the other stations. As to this last question, I am waiting for the opportunity of making more appropriate research.

As I said in the beginning, we have limited ourselves up to the present to the calculation and publishing of provisional results. We have however prepared and commenced the work also for the definitive reduction with appropriate discussion of all results; if at the present time the work is not fully going on, it is due to the following two reasons. First of all, the definitive results for the years 1930·0–1936·0 are not yet available, which makes it difficult for us to connect them with the later observations. Such connection seems to be made still more difficult by the alterations in the programme of observations in the year 1935. And, while Prof. Kimura may find difficulties in the reduction of the observations in 1935, owing to the scarcity of the material of observation at his disposal, it seems to us that it is not desirable to isolate the treatment of the observations subsequent to 1936·0. It would be useful if the observations of 1935, after being calculated and discussed by Prof. Kimura, could be examined here a second time together with the later observations. The second reason which has till now delayed the definite elaboration of the large material of observations, is that the limited means at our disposal prevents us from engaging a larger number of calculators. Concerning the future, or more properly the current work, I propose to continue the reductions, as has been done till now. The ephemerides will be calculated and distributed in due time to those who are interested in them. It is my wish to add also, for each pair, the constant value, still provisional, of the correction of the average of the two declinations obtained from the discussion of the observations of the first two years. It would then be possible, for those who wish to do so, to take into consideration such corrections, in order that they may obtain results that are more concordant among themselves, and more easily comparable. Finally, after the evident superiority of the results obtained by combining together the northern and the southern stations, it seems to me that the moment has come to limit our work to this method, abandoning the separate reduction of the northern stations only.

I conclude this report by pointing out the long, patient and diligent work of Prof. Paolo Vocca, who superintended, directed and checked all the calculations, in which have participated Miss E. Pisano and Miss V. Esposito from the beginning of 1936; Miss A. Chiarazzo and Miss A. de Maria from August 1936; Miss G. Pizza and Miss A. Salzano from August 1937. Dr A. Crisci was partially employed in the calculations from January 1936 to September 1937.

I am pleased to be able to add that the expenses of the Central Bureau have been met in the first two years by the yearly contributions of 10,000 lire granted by the Italian Ministry of National Education and by the National Research Council, and by two annual contributions of £112 from the International Astronomical Union, and by the contribution of 7000 francs in 1936, and 8200 francs in 1937 from the International Geodetic Association.

LUIGI CARNERA

Capodimonte, April 21, 1938

B 1. Report on Latitude Variation Observations at Greenwich, 1911–36, by Dr H. Spencer Jones

Observations were made with the Cookson Floating Zenith Telescope at Greenwich on a uniform plan, and with the minimum possible changes in the star-programme for a period of twenty-five years, from 1911 to 1936. The programme was initially planned for the determination of the constant of aberration as well as of the variation of latitude and was in the form of two interlacing Küstner polygons, the evening and morning observations being as widely separated in right ascension as possible.

In 1936 the position of the instrument was changed, so as to be adjacent to the new Reversible Transit Circle. At the same time a new programme of observations was introduced, three groups of stars centred around midnight being observed. A discussion of the observations for the period 1911 to 1936 has been made.

The observations for each star-pair were first approximately freed from the effects of latitude variation, by using provisional values of the variation. Corrections to the position for 1925·0 and to the proper-motion of each pair were derived. These improved positions and proper-motions (which, it may be noted, necessarily leave the general system of positions and proper-motions, which was based entirely on meridian observations, unaltered) were used as the basis for the subsequent discussion.

The observations were represented by the expression

$$z_p + t_q + S \sin(\odot - \alpha) + c\cos\theta + s\sin\theta + c'\kappa\cos\theta + s'\kappa\sin\theta = \text{(Obs.-Tab.) Z.D. north},$$

where z_p is the group correction to the pth group and t_q is the latitude correction in the qth period. S, c, s, c', s' are constants which have to be determined.

The term in S takes account of the systematic difference between evening and morning latitudes (which appears as closing error in the observations of the International Latitude Service); $\odot$ denotes the longitude of the Sun and α the mean right ascension of the group. A term of this form permits of the interpretation of S as involving a correction to the constant of aberration, or it may be regarded as a representation of a diurnal change in latitude during the night. Such a diurnal change would be due, presumably, to meteorological causes.

The terms in c and s take account of the effect of wind direction, θ being the wind direction measured from N through E. The terms in c', s' allow for a possible dependence on wind velocity, κ being $(v-10)/10$, where v is the velocity in miles per hour.

The result of the solution, by the method of least squares, gave

$$S = -0''{\cdot}0151 \pm 0''{\cdot}0024$$

$$s = +0''{\cdot}0254 \pm 0''{\cdot}0019 \qquad s' = -0''{\cdot}0015 \pm 0''{\cdot}0047$$

$$c = +0''{\cdot}0472 \pm 0''{\cdot}0019 \qquad c' = +0''{\cdot}0023 \pm 0''{\cdot}0047\,.$$

The S term, if interpreted as due to the use of an incorrect constant of aberration, leads to a value that corresponds to a solar parallax $\pi = 8''{\cdot}796 \pm 0''{\cdot}0013$. It is not considered, however, that this interpretation is justifiable and it is thought that a slight shift in the apparent position of the zenith during the night is a more probable explanation.

The wind-direction terms give an effect represented by $0''\cdot054 \cos(\theta - 28^\circ\cdot3)$, which has its greatest values for NNE and SSW winds. The effect is such that, with NNE winds, there is an apparent displacement of the zenith to the south.

Both s' and c' are smaller than their probable errors, so that no effect dependent upon wind velocity has been detected.

The observed latitudes were corrected for the diurnal term and the wind direction effect. It was found that the position of the *mean* pole relative to Greenwich had not varied by more than $0''\cdot05$ during the twenty-five years of observation.

From a comparison of evening and morning observations (groups with different nutation factors but the same latitude variation) the constant of nutation was derived. The value obtained was $9''\cdot217 \pm 0''\cdot004$. With Oort's value of the constant of precession (corrected for the relativity term), this constant of nutation corresponds to the value 81·59 for the reciprocal of the mass of the Moon.

The earth-tide in latitude variation was investigated and an effect was obtained represented by $(0''\cdot0037 \pm 0''\cdot0011) \cos(2t - 0^\circ\cdot3)$, where t is the hour-angle of the true Moon.

Full details will be given in due course in a Greenwich publication.

B2. Report on Observations of Latitude in the U.S.S.R., 1935–38, by A. J. Orlov

1. *Pulkovo.* The observations of latitude variations were continued with the zenith-telescope and by transit in the prime vertical. Much attention was given to the working up and publication of old observations. The observations of A. Pedashenko made in 1896·3–1902·3 with the transit in the prime vertical and computed by A. S. Wassilieff were published (Publ. s. II, vol. XLVIII, 1936); a reduction of two series of observations with the zenith-telescope (1920–25·5 and 1925·5–29·0) was finished. The observations in the latter programme extended throughout the whole night and give valuable data for the diurnal term in latitude variations. W. R. Berg obtained from all observations from 1915 to 1929 a mean diurnal variation of $0''\cdot04 \cos(t + 8^h)$ with excellent accordance of the separate series. Wassilieff, on the other hand, obtained from observations in the prime vertical a variation of $0''\cdot17 \cos(t + 13^h)$, similar values for the diurnal term being derived from observations of declinations with the vertical circles in Pulkovo and Odessa. A. J. Orlov, comparing annual variations of latitude in Pulkovo, obtained from observations of δ Cassiopeiae with the zenith-telescope (1905–17), with the results of the International Latitude Service, finds no diurnal latitude variation at all.

W. R. Berg finds that the z-term in Pulkovo has different values in different years, but on the average it did not change with the programme and is similar to the z-term of the International Latitude Stations. No variation of the mean latitude in 1933 and 1934 has been found.

Observations with the zenith-telescope have been continued from 1929 to the present time and are made according to the usual chain method with two-hour groups. A. S. Wassilieff made about 6000 observations with the transit in the prime vertical. The results of all Pulkovo observations are nearly ready for print.

2. *Moscow.* The Sternberg Astronomical Institute is working on the problem of Esclangon, who pointed out the importance of determining the coordinates of the pole in relation to a fixed mean position for the whole time of the international

observations. A. J. Orlov has shown that the mean pole does not move and has therefore a fixed position, to which the coordinates of the instantaneous pole are referred if the observations of latitude are freed from the slow variations not depending upon the motion of the pole. By this method new coordinates of the instantaneous pole were computed from 1891·5 to 1936·9 referred to the same mean pole. To increase the precision the coordinates were computed from 1916 to 1936 not only according to the International Latitude Service on parallel 39° 8′, but also from the observations at Pulkovo, Greenwich and Washington.

A. J. Orlov proposes to represent the coordinates of the pole in the form

$$x = x_c + x_a, \qquad y = y_c + y_a,$$

where x_a and y_a are the mean annual variations of these coordinates. From all observations 1891·5–1936·9 the following values of x_a and y_a were obtained:

Fraction of the year	x_a	y_a
0·0	−0″·033	−0″·070
·1	− ·074	− ·041
·2	− ·087	+ ·003
·3	− ·066	+ ·046
·4	− ·020	+ ·071
·5	+ ·033	+ ·070
·6	+ ·074	+ ·041
·7	+ ·087	− ·003
·8	+ ·066	− ·046
·9	+ ·020	− ·071

The curve $x_c = x - x_a$, $y_c = y - y_a$ represents very nearly the free nutation.

A detailed analysis of the motion of the pole for the period 1927–37 is in the press, and will shortly appear.

C. Recommendations from Members of the Commission

(*a*) *Von Dr R. Schumann über die Polhöhen-Schwankungen des Jahres* 1936–37, *auf* 8 *Stationen des Internationalen Breitendienstes nebst zwei Vorschlägen.*

In Nr. 6290 der *Astronomischen Nachrichten* erstattet L. Carnera einen interessanten Bericht* über die Breitenvariation 1936·0–37·0 auf den 5 Stationen des Internationalen Parallels (+39°) Mizusawa, Kitab, Carloforte, Gaithersburg, Ukiah, sowie in Batavia (−7°), in Nuova Adelaide und La Plata (−35°); die Beobachtung erfolgte dem Programme gemäss von 1922·7 ab sehr nahe zu den Tagesstunden $23^{h}\cdot 0$ (ser.) und $1^{h}\cdot 0$ (matt.); das frühere Reduktionsverfahren wurde beibehalten zur Ableitung einer "Polbahn".

Die nachfolgenden Abschnitte enthalten Beiträge zu einer Diskussion der beobachteten Polhöhen-Schwankungen, im Besonderen einiger der dabei wiederum auftretenden Widersprüche.

* "Il movimento del Polo di rotazione terrestre nel 1936." Von L. Carnera. *Astron. Nachr.* Bd. **263**, Nr. 6290, S. 18–32, 1937 Juni.

I

(1) In dem ausgedehnten Beobachtungs-Material erscheinen, neben den zur Berechnung von Polbahn-Koordinaten dienenden Fluktuationen fortgesetzt noch andere Fluktuationen, deren Ursachen zur Zeit nicht ausreichend geklärt sind, so dass eine erschöpfende, einwandfreie Reduktion noch nicht erfolgen konnte. Um die bei Ableitung der hier nebensächlichen Deklinations-Verbesserungen $\Delta\delta$ auftretenden Missstimmigkeiten wenigstens rechnerisch zu beseitigen, werden fortgesetzt empirische, goniometrische Glieder* angesetzt mit den von der Sonnenlänge $\odot$ und der Rektascension α der Gruppensterne abhängigen Argumenten: $\odot-\alpha$, $2\odot-\alpha$ und $2(\odot-\alpha)$ und ihre numerischen Konstanten nach der M.d.kl.Q. bestimmt. Man findet in Carnera's Tabellen 1 und 2 zunächst die unveränderten Gruppenmittel für 1936·0 bis 1937·0, getrennt nach den Tagesstunden (ser. und matt.), in Tabelle 9 die $\Delta\phi$ bezogen auf gute Mittelwerte der Stationsbreiten und korrigiert um die erwähnten Glieder, aber noch behaftet mit den $\Delta\delta$. Da sich die Beobachtungen über ein volles Jahr erstrecken, so lassen sich Schlussfehler sowohl *vor* als *nach* Anbringung jener Glieder bilden; sie sind:

TABELLE I

	Schlussfehler	
	Ohne emp. Glied	Mit emp. Glied
	″	″
Mizusawa	−0·065	−0·233
Kitab	− ·048	+ ·038
Carloforte	+ ·005	+ ·071
Gaithersburg	− ·356	− ·609
Ukiah	− ·053	− ·246
Nuova Adelaide	− ·128	− ·114
Batavia	+ ·093	—
La Plata	+ ·073	+ ·073

Danach treten merklich vergrösserte Schlussfehler auf in Mizusawa, Carloforte, Gaithersburg und Ukiah; es sei daran erinnert, dass der theoretische Wert eines Schlussfehlers ≡ null ist, ferner, dass aus anderweitigen mehrjährigen Reihen für ihn als äusserer mittlerer Fehler $\pm 0''\cdot 1$, aus mehreren Schlussfehlerkurven gemäss dem Abbe'schen Kriterium als innerer mittlerer Fehler aber nur $\pm 0''\cdot 03$ folgt. Die Unterschiede in obiger Tabelle I hängen eng zusammen mit dem Zwölffachen der oben erwähnten empirischen Glieder, in Uebereinstimmung mit der bezüglichen Bemerkung L. Carnera's (*loc. cit.* S. 22).

(2) Den für die Berechnung der $\Delta\delta$ benötigten Differenzen zwischen je zwei abschnittweisen Gruppenmitteln gibt L. Carnera zweckmässigerweise die Form

$$+2r_1 . \sin 15^\circ . \cos(\odot_m-\alpha+A_1+15^\circ)$$
$$+2r_2 . \sin 30^\circ . \cos(2\odot_m-\alpha+A_2+30^\circ)$$
$$+2s . \sin 30^\circ . \cos(2\odot_m-2\alpha+S+30^\circ)$$

r_1, r_2, s, A_1, A_2, S bedeuten zu bestimmende Konstanten, der Index m kennzeichnet die Beobachtungen morgens 1^h (matt.).

* *Results of the International Latitude Service from* 1922·7 *to* 1931·0. Vol. 7. By Hisashi Kimura. Mizusawa, 1935.

Um die Wirkungsweise dieser Glieder näher erkennen zu können, ist es ratsam, sich die Reihen der zeitlichen Argumente zu betrachten, wie sie sich nach dem Beobachtungsprogramme ergeben:

TABELLE II

Zeitliche Argumente

Jahres-Bruch	Gruppen	⊙	α 23h ser.	α 1h matt.	⊙−α 23h ser.	⊙−α 1h matt.	2⊙−α 23h ser.	2⊙−α 1h matt.	2(⊙−α) 23h ser.	2(⊙−α) 1h matt.
·06	IV, V	301°	106°	136°	195°	165°	136°	106°	30°	330°
·17	V, VI	330	136	167	194	163	164	133	28	326
·22	VI, VII	359	167	196	192	163	191	162	24	326
·31	VII, VIII	32	196	228	196	164	228	196	32	328
·39	VIII, IX	60	228	256	192	164	252	224	24	328
·47	IX, X	89	256	285	193	164	282	253	26	328
·56	X, XI	119	285	316	194	163	313	282	28	326
·63	XI, XII	146	316	345	190	161	336	307	20	322
·72	XII, I	176	345	16	191	160	7	336	22	320
·81	I, II	208	16	46	192	162	40	10	24	324
·88	II, III	236	46	75	190	161	66	37	20	322
·97	III, IV	267	75	106	192	161	99	68	24	322
				Mittel:	193	163			25	325

Infolge des regelmässigen Gruppenwechsels sind, wie Carnera bemerkt hat, die Argumente $\odot-\alpha$ und $2(\odot-\alpha)$ nahezu konstant; veränderlich ist das Argument $2\odot-\alpha$ und zwar, wie man schon aus der Form: $\odot+(\odot-\alpha)$ erkennt, mit der *einfachen* Sonnenlänge als Folge des ständigen Gruppenwechsels. Ein etwa vorhandener zweimaliger Umlauf im Jahre könnte damit nicht ermittelt werden, wie man schon am Verlaufe der Winkel in der Spalte $2\odot-\alpha$ in obiger Tabelle II erkennt. Demnach können die mehrfach erwähnten 3 kleinen Glieder durch eines von der Form: $\alpha+\beta\,.\cos(\odot+\gamma)$ ersetzt werden, das sprungweise veränderliche Argument α entfällt dabei.

(3) Nach *Astron. Nachr.* Nr. 6290, Spalten 22 und 25 findet L. Carnera gemäss der Form: $a_1+r_2\,.\sin(2\odot_m-\alpha\pm A_2)$ zwei Systeme für die Konstanten a_1, r_2 und A_2; je nachdem die beiden Südstationen auf $-35°$ zu einem Ausgleich mit den 5 Nordstationen zusammen verwendet werden oder nicht. Die einzelne Station Batavia auf $-7°$ wurde nicht zugezogen. Zum Vergleiche sind hier die beiden Systeme nebeneinander gestellt.

TABELLE III

	λ W. Gr.	Parallel-Kreis +39°. 5 Stationen a_1	r_2	A_2	Parallel-Kreise +39° und −35°. 7 Stationen a_1	r_2	A_2
	°	″	″	°	″	″	°
Mizusawa	−141	−0·034	+0·065	+40	−0·014	+0·021	−116
Kitab	− 67	− ·031	+ ·080	+24	+ ·003	+ ·024	+ 10
Carloforte	− 8	− ·014	+ ·035	− 3	+ ·004	+ ·034	− 38
Gaithersburg	+ 77	− ·030	+ ·038	−55	− ·021	+ ·012	− 80
Ukiah	+123	− ·006	+ ·030	−63	− ·016	+ ·015	− 44
Nuova Adelaide	−138	—	—	—	+ ·001	+ ·037	+ 12
La Plata	+ 58	—	—	—	·000	+ ·026	− 81

Die 5 Systeme des Nordparallels zeigen eine gute Harmonie unter sich; nach Hinzutritt der zwei Südstationen sind die a_1 und r_2 im allgemeinen auffällig kleiner geworden, der Gang in den A_2 wird zerstört. Trotz der Vergrösserung der Anzahl der Stationen erscheint diese Ausdehnung des Ausgleiches auf Stationen verschiedener Breite nicht angebracht, regionsweise Unterschiede machen sich geltend.

II

Die übliche Lösung der Aufgabe: Bestimmung der Schwankung von Stations-Polhöhen wird belastet durch das Hinzutreten der hier nebensächlichen Deklinations-Verbesserungen $\Delta\delta$ als neue Unbekannten. Bei den Bemühungen, sie mit zu bestimmen, machen sich kleine, täglich periodische Einflüsse geltend, mögen es eigentliche oder uneigentliche Polhöhenschwankungen sein. Die dafür angesetzten einfachen Sinus-Glieder mit den Argumenten $\odot-\alpha$, $2\odot-\alpha$ und $2(\odot-\alpha)$ sind analytisch, wegen ihrer Abhängigkeit von α, zwar täglich periodische Funktionen; bei der kurzen Epochendifferenz von 2^h ist es aber unmöglich, die Uebereinstimmung mit der Wirklichkeit während der übrigen 22^h des Tages zu erkennen, dazu wären Beobachtungen tagsüber erforderlich.

Streng genommen werden im Laufe des Jahres nur Folgen von Ordinaten isolierter Punkte beobachtet, die allerdings scheinbar stetige Kurven bilden; dabei ist Interpolation nach Stunden nicht erlaubt. Eine Schar von Tageskurven, konstruiert aus der berühmten Aberrationsreihe W. Struve's,* liess erkennen, dass eine entsprechende tägliche Periodizität kein einfaches Sinusgesetz befolgt. Solche Einflüsse kurzperiodischer Schwankungen, die den gemessenen langperiodischen (von 12, 14 Monaten u.s.w.) superponiert sind, können sich numerisch geltend machen bei den Bestimmungen der $\Delta\delta$, der Stationspolhöhen, der Schlussfehler und der $\Sigma\Delta\Phi$; die *Beträge* können bei den $\Delta\delta$, den Polhöhen und den $\Sigma\Delta\Phi$ $0''\cdot05$ überschreiten und $0''\cdot1$ erreichen, bei den Schlussfehlern zeitweise $1''$ überschreiten.

Die auf übliche Art abgeleiteten Stationspolhöhen bleiben abhängig von den Fehlern der $\Delta\delta$, aber die aus den $\Delta\delta$ berechneten Schlussfehler sind, nach der Summation über je 12 sukzessive Gruppenmittel-Differenzen vom gleichen Tage, in Strenge frei von ihnen, also nach Ablauf eines Jahres; im Gegensatz hierzu ist in den $\Sigma\Delta\Phi$ jedes einzelne $\Delta\Phi$, als Differenz der beiden abschnittweisen Mittel *derselben* Gruppe $\Delta\delta$-frei, also schon nach Ablauf eines Monats. Im Folgenden sollen aus den $\Sigma\Delta\Phi$ für die 8 Stationen des Internationalen Breitendienstes Polhöhen-Kurven abgeleitet werden; nach dem Gesagten entfällt dabei die Bestimmung der ohnedies nebensächlichen Deklinations-Verbesserungen.

Aus den Tabellen 1 und 2 L. Carnera's ergeben sich die Σ der Tabelle IV.

Eine graphische Darstellung führte vor Augen, dass diese Σ-Kurven unter Schwankungen zumeist ab-, seltener anstiegen, ähnlich wie früher veröffentlichte, in verschiedenem Grade auf verschiedenen Stationen. Erfahrung lehrte, dass dieses Ab- oder Ansteigen für die Dauer eines Jahres als nahezu konstant angesehen und ermittelt werden kann entweder: durch Mitführen linearer Glieder bei Gesamt-Ausgleichen, oder durch Teilausgleiche, oder schrittweise nach Abzug von Approximationen für die Schwankungen. Methoden der Schwankungs-Bestimmung, die in Strenge frei sind von den $\Delta\delta$ und keiner Approximationen bedürfen, sind vor

* "Numerische Untersuchung über Polhöhenschwankung und Aberrationskonstante." Von R. Schumann. *Astron. Abhandlungen* als Ergänzungshefte der *Astron. Nachr.* Nr. 11, 1906. Darin § 8 und Tafel II. Siehe auch Tabelle 46 der Σ-Differenzen.

Jahren ausgearbeitet und veröffentlicht worden von K. Ledersteger,* J. H. G. Schepers† und dem Autor;‡ für die vorliegende Untersuchung des Jahrganges 1936/37 liessen sich leicht Approximationen aus L. Carnera's Tabellen 1 und 2 ermitteln nach dem von 1900·0 ab üblichen Reduktions-Verfahren. Empirische goniometrische Glieder anzubringen wurde abgelehnt.

Tabelle IV

Polhöhen-Schwankungen

λ=	Mizusawa −141°		Kitab −67°		Carloforte −8°		Gaithersburg +77°		Ukiah +123°	
J.-B.	Σ	φ	Σ	φ	Σ	φ	Σ	φ	Σ	φ
	″	″	″	″	″	″	″	″	″	″
·06	0·000	+0·119	0·000	−0·036	0·000	−0·037	0·000	+0·095	0·000	+0·077
·14	− ·021	+ ·023	+ ·046	− ·029	− ·049	− ·023	− ·022	+ ·038	+ ·030	+ ·098
·22	− ·047	+ ·042	− ·023	− ·073	− ·057	− ·044	− ·104	− ·014	+ ·004	+ ·092
·31	− ·192	− ·050	− ·062	− ·071	− ·061	− ·007	− ·146	+ ·002	− ·037	+ ·057
·39	− ·249	− ·088	− ·072	− ·075	− ·101	− ·010	− ·205	+ ·030	− ·147	− ·003
·47	− ·305	− ·116	− ·059	− ·035	+ ·009	+ ·096	− ·275	+ ·024	− ·242	− ·046
·56	− ·355	− ·148	− ·032	− ·001	− ·029	+ ·055	− ·383	− ·028	− ·271	− ·072
·64	− ·218	− ·040	+ ·073	+ ·095	− ·015	+ ·045	− ·356	+ ·042	− ·276	− ·091
·72	− ·091	+ ·046	+ ·050	+ ·058	− ·045	+ ·014	− ·479	− ·046	− ·268	− ·090
·81	− ·113	+ ·045	+ ·041	+ ·056	− ·049	+ ·010	− ·519	− ·061	− ·226	− ·047
·89	− ·078	+ ·099	+ ·111	+ ·102	− ·070	− ·003	− ·566	− ·091	− ·205	− ·016
·97	− ·143	+ ·068	+ ·026	+ ·013	− ·089	− ·099	− ·489	+ ·009	− ·137	+ ·041

λ=	N. Adelaide −138°		Batavia −107°		La Plata +58°	
J.-B.	Σ	φ	Σ	φ	Σ	φ
	″	″	″	″	″	″
·06	0·000	+0·170	0·000	−0·039	0·000	+0·040
·14	− ·165	+ ·027	·000	− ·047	+ ·055	+ ·078
·22	− ·173	+ ·010	− ·025	− ·080	+ ·090	+ ·127
·31	− ·204	− ·022	− ·025	− ·087	+ ·019	+ ·061
·39	− ·298	− ·087	− ·077	− ·147	+ ·043	+ ·061
·47	− ·401	− ·156	− ·073	− ·151	+ ·022	+ ·010
·56	− ·345	− ·096	+ ·042	− ·044	+ ·013	·000
·64	− ·271	− ·038	+ ·108	+ ·014	+ ·031	+ ·040
·72	− ·236	+ ·012	+ ·219	+ ·118	− ·077	− ·079
·81	− ·313	− ·018	+ ·275	+ ·166	− ·087	− ·132
·89	− ·208	+ ·098	+ ·321	+ ·204	− ·074	− ·124
·97	− ·178	+ ·105	+ ·218	+ ·093	− ·059	− ·082

Hiernach ergaben sich für die Schwankungen der Polhöhen auf den 8 Stationen die Werte der Spalte ϕ in Tabelle IV, aus ihr weiter die Werte $\Sigma - \phi$ in Tabelle V.

* "Eine neue Methode zur Berechnung der 'Polbahn'." Von K. Ledersteger. *Astron. Nachr.* Bd. **243**, Nr. 5813–14, 1931.

† "Jaarverslag van den topografischen Dienst in Nederlandsch-Indië." Jahrgänge 1929–32, Abschnitte über Breitenvariation bearbeitet von J. H. G. Schepers. Hierin werden die $\Sigma\Delta\Phi$ bezeichnet durch [$\Delta\phi$].

‡ "Ueber Schwankungen der Stations-Polhöhen des Internationalen Breitendienstes." Von R. Schumann. *Astr. Nachr.* Bd. **251/2**, Nr. 6022/23 und 6027, 1934. Im besonderen siehe wegen der Glieder mit der doppelten Sonnenlänge die Tabellen 29 und 30, wegen Abhängigkeit von λ die Tabelle 28.

TABELLE V

$+\Sigma-\phi$

J.-B.	Mizu.	Kitab	Carlof.	Gaith.	Ukiah	N. Ad.	Bat.	La Pl.
	"	"	"	"	"	"	"	"
·06	−0·119	+0·036	+0·037	−0·095	−0·077	−0·170	+0·039	−0·040
·14	− ·044	+ ·075	− ·026	− ·060	− ·068	− ·192	+ ·047	− ·023
·22	− ·089	+ ·050	− ·013	− ·090	− ·088	− ·183	+ ·055	− ·037
·31	− ·142	+ ·009	− ·054	− ·148	− ·094	− ·182	+ ·062	− ·042
·39	− ·161	+ ·003	− ·091	− ·235	− ·144	− ·211	+ ·070	− ·018
·47	− ·189	− ·024	− ·087	− ·299	− ·196	− ·245	+ ·078	+ ·012
·56	− ·207	− ·031	− ·084	− ·355	− ·199	− ·249	+ ·086	+ ·013
·64	− ·178	− ·022	− ·060	− ·398	− ·185	− ·233	+ ·094	− ·009
·72	− ·137	− ·008	− ·059	− ·433	− ·178	− ·248	+ ·101	+ ·002
·81	− ·158	− ·015	− ·059	− ·458	− ·179	− ·295	+ ·109	+ ·045
·89	− ·177	+ ·009	− ·067	− ·475	− ·189	− ·306	+ ·117	+ ·050
·97	− ·211	+ ·013	+ ·010	− ·498	− ·178	− ·283	+ ·125	+ ·023

Diese Werte dienten zu einem Ausgleich nach der linearen Form: $a+b.t$ mit den beiden örtlichen Konstanten a und b, die Zeiteinheit für t ist der durchschnittliche Monat. Das Ergebnis des Ausgleiches findet sich in Tabelle VI.

TABELLE VI

	a	*b*
	" "	" "
Mizusawa	−0·098 ± 0·020	−0·010 ± 0·003
Kitab	+ ·036 ± ·015	− ·005 ± ·002
Carloforte	− ·028 ± ·017	− ·003 ± ·003
Gaithersburg	− ·051 ± ·020	− ·044 ± ,003
Ukiah	− ·083 ± ·025	− ·012 ± ·002
Batavia	+ ·039 —	+ ·008 —
Nuova Adelaide	− ·167 ± ·009	− ·012 ± ·001
La Plata	− ·044 ± ·009	+ ·008 ± ·001

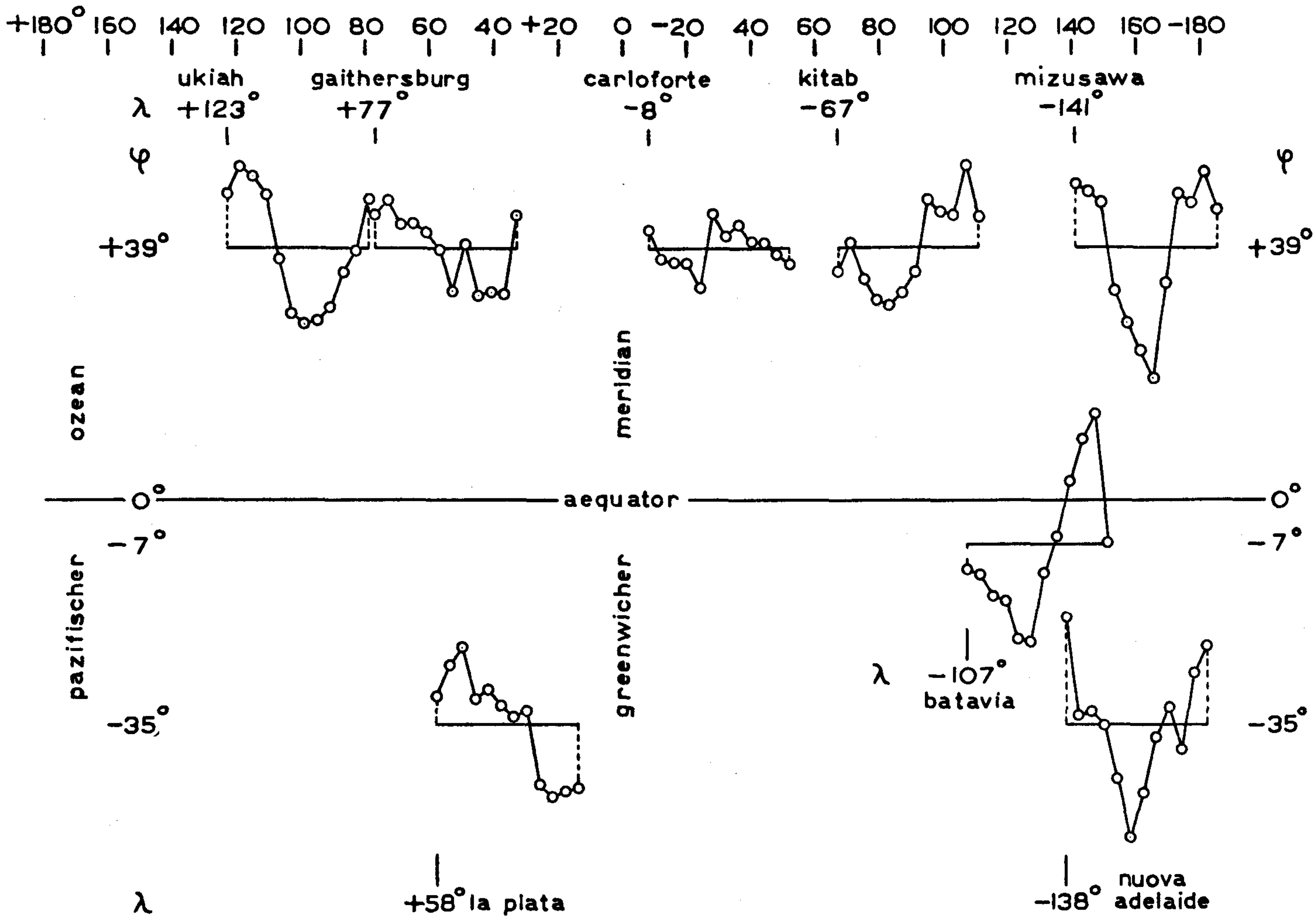
Hiermit wurden die $\Delta\delta$-freien Σ der Tabelle IV von dem Ab- oder Ansteigen befreit; es ergaben sich so aus den $\Sigma\Delta\Phi$ die Polhöhen-Schwankungen der Tabelle VII.

TABELLE VII

$\Sigma-$Polhöhen-Schwankungen

J.-B.	Mizu.	Kitab	Carlof.	Gaith.	Ukiah	N. Ad.	Bat.	La Pl.
	"	"	"	"	"	"	"	"
·06	+0·098	−0·036	+0·029	+0·051	+0·083	+0·167	−0·039	+0·044
·14	+ ·087	+ ·015	− ·017	+ ·073	+ ·125	+ ·014	− ·047	+ ·091
·22	+ ·070	− ·049	− ·022	+ ·036	+ ·111	+ ·018	− ·080	+ ·119
·31	− ·065	− ·081	− ·023	+ ·038	+ ·081	− ·001	− ·087	+ ·040
·39	− ·113	− ·088	− ·060	+ ·024	− ·017	− ·083	− ·147	+ ·054
·47	− ·159	− ·069	+ ·054	− ·002	− ·100	− ·174	− ·151	+ ·028
·56	− ·200	− ·037	+ ·019	− ·065	− ·117	− ·106	− ·044	+ ·011
·64	− ·053	+ ·073	+ ·036	+ ·006	− ·110	− ·020	+ ·014	+ ·022
·72	+ ·084	+ ·055	+ ·009	− ·072	− ·091	+ ·027	+ ·108	− ·094
·81	+ ·071	+ ·051	+ ·008	− ·068	− ·037	− ·038	+ ·166	− ·112
·89	+ ·116	+ ·126	− ·009	− ·070	− ·004	+ ·079	+ ·204	− ·106
·97	+ ·060	+ ·047	− ·025	+ ·051	+ ·076	+ ·121	+ ·003	− ·099

Sie bilden die Unterlage für die Tafel auf Seite 140. Dabei entsprechen: bei den geographischen Koordinaten 1 cm. in Breite einem Bogen von 10°·7, in Länge von



$\Sigma\Delta\Phi$ = Polhöhen-Schwankungen auf 8 Stationen, $\Delta\delta$-frei, geographisch geordnet.

$21^\circ.4$; bei den Schwankungen 1 mm. einem Bogen von $0''.0107$, auf der Zeitachse 2 mm. 1·07 Monat.

Um die Bindung der Schwankung an die Station und damit an die Erdscholle hervortreten zu lassen, sind die Kurven angenähert geographisch angeordnet.

Beim einfachen Ueberblicken dieser Zone zwischen den Breiten $+39^\circ$ und -35° darf man, wenn auch keineswegs durchgehend, eine angenäherte streifenweise Zusammengehörigkeit in nordsüdlicher Richtung vermuten (siehe oben Tabelle III). Die Schwankung in La Plata, auf den Parallel $+39^\circ$ verschoben, schaltet sich nicht gut zwischen Carloforte und Gaithersburg. Die Zone umfasst 1/4 bis 1/3 der Erdoberfläche; die Abstände bis zu den beiden Erdpolen betragen rund 5·700 km. im Norden, 6·100 km. im Süden, bei 8·200 km. nordsüdlicher Erstreckung der Zone. Im Hinblick auf Beweglichkeit von Erdschollen entstehen Fragen folgender Art: wie streng ist die Abhängigkeit der Polhöhenschwankungen von der Länge λ? Ist es erlaubt, Schwankungen auf rund 6,000 km., unverändert zu übertragen? Entsprechen sich die "Bahnen" des Nord- und des Südpoles, wie es die Annahme einer "Erdachse" verlangt? Aendert sich die Schwankung mit der geographischen Breite oder nicht? Zur Klärung könnten Kontrollmessungen auf Stationen in höheren Breiten beitragen.

III

Aus mehrfachen Darstellungen im Laufe der vorliegenden numerischen Untersuchung erwies sich im allgemeinen die Genauigkeit der Messungen auf den jüngeren Stationen als gleichwertig mit der auf den älteren.

Im einzelnen bleiben bei obigem linearem Ausgleich der fünf $\Sigma - \phi$-Reihen des 39. Parallels Reste übrig, die, in schöner Uebereinstimmung zwischen den Stationen, eine jährliche Periodicität aufweisen. Durch Ansatz zweier Glieder:

$$c \,.\, \cos \odot + s \,.\, \sin \odot$$

zu einem Ausgleich fand sich das System:

	$+\beta \;.\; \cos(\odot + \gamma)$
	$''$ $\qquad\qquad\qquad ^\circ$
Mizusawa	$+0.025 \,.\, \cos(\odot - 5.6)$
Kitab	$+0.030 \,.\, \cos(\odot - 23.4)$
Carloforte	$+0.043 \,.\, \cos(\odot - 10.9)$
Gaithersburg	$+0.030 \,.\, \cos(\odot - 55.8)$
Ukiah	$+0.031 \,.\, \cos(\odot - 24.4)$
Mittel für Par.-Kr. $+39^\circ$	$+0.032 \,.\, \cos(\odot - 24.0)$
	$\pm 0.003 \qquad\qquad \pm 8.7$

Die übrig bleibenden Reste zeigten auf allen Stationen wiederum Vorzeichenfolgen, sie lassen einen zweimaligen Umlauf im Jahre* vermuten; setzt man sie als Funktion an nach einer Form: $c_2 \,.\, \cos 2\odot + s_2 \,.\, \sin 2\odot$, so folgt durch Ausgleich:

	$+\beta_2 \;.\; \cos 2(\odot + \gamma_2)$
	$''$ $\qquad\qquad\qquad ^\circ$
Mizusawa	$+0.033 \,.\, \cos 2(\odot + 43)$
Kitab	$+0.007 \,.\, \cos 2(\odot + 37)$
Carloforte	$+0.014 \,.\, \cos 2(\odot + 95)$
Gaithersburg	$+0.022 \,.\, \cos 2(\odot + 11)$
Ukiah	$+0.016 \,.\, \cos 2(\odot + 27)$
Mittel	$+0.018 \,.\, \cos 2(\odot + 43)$
	$\pm 0.004 \qquad\qquad \pm 14)$

* R. Schumann, *Astr. Nachr.* Bd. **251–2**, Nr. 6022–3 und 6027, 1934.

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Die nunmehr nach drei Teil-Ausgleichen der $\Sigma-\phi$ übrig bleibenden Reste sind (Tabelle VIII):

TABELLE VIII

Übrigbleibende Fehler

J.-B.	Mizu.	Kitab	Carlof.	Gaith.	Ukiah	Quadrat. Mittel	Stern-paare
	"	"	"	"	"	"	
·06	+0·026	+0·026	−0·011	+0·048	+0·011	±0·028 Ma	370 Mi
·14	− ·035	− ·018	+ ·033	− ·018	− ·003	± ·024	396
·22	+ ·007	− ·006	− ·017	− ·016	+ ·007	± ·012	481
·31	+ ·020	+ ·012	− ·015	− ·003	− ·014	± ·014	531
·39	− ·010	− ·008	+ ·005	+ ·016	− ·003	± ·009	722
·47	− ·015	+ ·001	+ ·003	− ·001	+ ·013	± ·009	656
·56	+ ·010	·000	+ ·006	− ·011	− ·001	± ·007 Mi	843 Ma
·64	+ ·007	− ·003	− ·012	− ·008	− ·011	± ·009	796
·73	− ·010	− ·006	− ·008	+ ·008	− ·003	± ·008	746
·80	+ ·006	+ ·013	+ ·004	+ ·015	+ ·009	± ·010	608
·88	− ·009	− ·010	+ ·024	− ·008	+ ·006	± ·013	482
·97	·000	− ·014	− ·029	− ·036	− ·020	± ·023	479
Quadrat. Mittel	± ·017	± ·013	± ·018	± ·022	± ·011		
Sternpaare	1059	1545	1638	1348	1520		7110

Die Vorzeichen dieser im allgemeinen kleinen Reste erscheinen nunmehr spaltenweise zufällig verteilt; der Jahresgang der quadratischen Mittel (vorletzte Spalte) dürfte mit Gunst und Ungunst der Witterung, mittelbar auch mit der Anzahl der Sternpaare (letzte Spalte) eng zusammenhängen.

Hiernach scheint mittels einer rein empirischen Formel:

$$+a+b\,.\,t+c\,.\cos\odot+s\,.\sin\odot+c_2\,.\cos 2\odot+s_2\,.\sin 2\odot$$

im Durchschnitt als Grenze der Darstellbarkeit ein mittlerer Fehler $\pm 0''{\cdot}01$ erreichbar zu sein bei einem Aufwand von 500 bis 600 Sternpaaren; bei einer kleineren Anzahl wächst der mittlere Fehler rascher an. Unverkürzt bleibt die Notwendigkeit bestehen, die Ursache dieser Schwankungen zu ergründen und dafür theoretische Formeln aufzustellen.

Den Resten in Tabelle VIII liegen $\Delta\delta$-freie Grössen Σ zugrunde, die ebenso wie die Schlussfehler durch sukzessive Summation aus Gruppenmittel-Differenzen, in diesem Falle über ein Jahr, erhalten wurden. Gegen sie kann der Einwand erhoben werden, dass nach der Theorie der Fehlerfortpflanzung ihre mittleren Fehler ständig anwachsen, ihre Gewichte also ständig abnehmen und zwar relativ am stärksten am Beginn der Summation. Aber es steht frei, zeitlich vom Ende der Reihe aus nach rückwärts* zu summieren; man erhält bis auf eine Konstante die gleiche Kurve, während die Reihen der mittleren Fehler und der Gewichte umgekehrt verlaufen. Wieder andere Fehler und Gewichte erhielte man bei einer ebenfalls erlaubten Summation von einer mittleren Epoche aus nach beiden Seiten u.s.w.

Bei der vorliegenden numerischen Untersuchung von Grössen $\Sigma\Delta\Phi$ auf den 5 Nordstationen müsste sich eine Zunahme der Unsicherheit zeigen, umsomehr als es sich um ein erstes Jahr handelt; der dabei vorgenommene lineare Ausgleich der Grössen $\Sigma-\phi$ nach $a+b\,.\,t$ kommt übrigens bei diesem gesuchten Anwachsen mittlerer Beobachtungsfehler nicht in Betracht.

Aber es ist weder in den einzelnen Fehlerreihen, noch in der Reihe der "quad-

* "Ueber die 4- Gruppenreihe G. A. Hills im I. Vertikale 1904–12." Von R. Schumann. *Astron. Nachr.* Bd. **229**, Nr. 5493/94, Sp. 425–426, Tab. 3.

ratischen Mittel" der Tabelle VIII ein Anwachsen mit dem Abstande vom Beginn der Summation ab zu erkennen. Selbst bei einer früheren Summation* über 22 Jahre liessen sich Anstiege der Unsicherheit mit der Zeit numerisch oder grafisch nicht erkennen. Diese sukzessiven $\Delta\Phi$-Summen verhalten sich erfahrungsgemäss wie direkt beobachtete Grössen,† für deren Fehler ϵ gilt‡: $\lim_{n=\infty} \frac{|\epsilon|}{n} = 0$.

Mit dem Ab- und Ansteigen der Σ hängen bekanntlich die Schlussfehler, ihrer Ableitung gemäss, eng zusammen; deren Herkunft ohne notwendige und hinreichende Begründung "meteorologischen Ursachen" oder der "Refraction" zuzuschieben, wie es bisweilen resigniert geschieht, geht nicht an; in diesem Sinne bezeichnet Walter D. Lambert letztere in seinem bekannten ausführlichen Berichte über die Breitenschwankungen drastisch als scape-goat. Es widersprechen einem solchen Zuschieben schon die stetigen *mehrjährigen* Schwankungen in den ausführlichen Schlussfehler-Reihen der älteren Bände der "Ergebnisse..."; Eigenheiten ihres Verlaufes können Anhalt bieten zum Aufdecken der Fehlerquellen. Sehr dankenswert war die bekannte, vor mehreren Jahrzehnten unternommene 4-Gruppenreihe in Mizusawa; aus den Kombinationen: 1. und 2., 2. und 3., 3. und 4. Abendreihe folgten§ recht verschiedene Σ-Reihen.

IV. Vorschläge

Im Anschluss an das Vorhergehende und unter Hinweis auf frühere Vorschläge|| seien hier die folgenden betont:

1. Einrichtung einer oder mehrerer Breitenstationen in hohen Breiten.
2. Wie in früheren Jahren erscheint auch künftighin Diskussion und ausführliche Wiedergabe der $\Delta\delta$-freien Schlussfehler-Reihen in den "Ergebnissen..." zweckmässig und geboten.

R. SCHUMANN

WIEN, 1938 *Februar*

(*b*) *Remarks by Dr H. Spencer Jones on the communication from Dr R. Schumann*

Dr R. Schumann in his communication raises questions both of principle and of methods of reduction. These questions become interlocked when a decision has to be made whether the observations at the two southern stations should be incorporated with those at the northern stations for the derivation of co-ordinates x and y, which are assumed to represent the path of the Pole. The difference of longitude of the two southern stations does not permit of an effective separation of the x and y components, so that comparison between the paths of the Pole derived from observations at the northern and southern stations separately is not possible. On the other hand, the observations at both northern and southern stations tend to be most numerous in the summer season and least numerous in the

* R. Schumann, *Astr. Nachr.* Bd. **251–2**, Nr. 6022–3 und 6027, 1934.

† "Eine Schätzung der Genauigkeit der Summen $\Sigma\Delta\Phi$." Von R. Schumann. *Astron. Nachr.* Bd. **255**, Nr. 6098.

‡ *Die Ausgleichsrechnung nach der M.d.kl.Q.* Von F. R. Helmert. II. Auflage, 1907, S. 340.

§ "Ueber Gezeitenerscheinungen in den Schwankungen der Stations-Polhöhen." Von R. Schumann. *Denkschriften der Kaiserlichen Akademie der Wissenschaften in Wien,* Bd. **89**, S. 317–400. Mit 3 Tafeln. Wien, 1913. Im besonderen Tabellen 35 u. folgende.

|| "Bemerkung über Berechnung und Beobachtung der Schwankungen von Stations-Polhöhen nebst Vorschlägen." Von R. Schumann. *Transactions of the International Astronomical Union,* Vol. **5**, S. 118–22, Cambridge, 1936.

winter season, so that by combining them the weights for the separate periods of observation become more uniform.

There is no certain evidence of changes in relative longitude or latitude of any two places on the Earth's surface. This is the justification for combining the latitude changes observed at different places in the deduction of the movements of the poles of the Earth's axis of rotation. But even if small displacements of one part of the crust of the Earth relative to other parts were known to exist, the representation of latitude variation observations by the x and y components of the polar motion would still be of value. By the combination of these two components, the major portion of the latitude variation at any place can be represented; the residual portion appears to be due in large measure to local meteorological effects.

Latitude variation observations serve two purposes. In meridian astronomy, it is necessary to apply corrections to observed declinations to allow for the variation of latitude. Unless the observatory that makes the meridian observations determines its own latitude variations, the best that it can do is to infer the variations of its latitude from the international values of x and y. This leaves the local meteorological effects in the observations. The second purpose is the theoretical study of the observed displacements. For this purpose also, it is of value to have the x and y components computed, so that any residual effects, which cannot be represented in this way, may be investigated.

I am of the opinion that it is advantageous to include the observations at the two southern stations along with those at the northern stations, for the determination of the polar motion, even though this introduces the further complication of an additional series of group corrections. I believe that the observations made at the equatorial station, Batavia, could also with advantage be incorporated.

The method of reduction that, following Kimura, is being used for the international results does not appear to me to be satisfactory. We consider, for example, the data given by Prof. Carnera in his presentation of the preliminary results for the year 1936 (*Ast. Nach.* **263**, No. 6290, June 1937). Four series of values of x and y are summarized in the table on p. 144.

In this table, the figures in the columns headed 1 and 3 represent the values of x and y, derived from the representation of the observations by the formula

$$\Delta\phi = \phi - \phi_0 = x \cos \lambda + y \sin \lambda + \Delta\delta', \qquad \ldots\ldots(1)$$

where $\Delta\delta'$ is assumed to be the same for all stations for any one group, evening or morning. The figures in the column headed 1 are derived from northern stations only; those in the column headed 3 are derived from northern and southern stations combined. The columns, headed 2 and 4, correspond respectively to northern stations only, and to the combination of northern and southern stations, when the differences in the $\Delta\delta$ values for evening and morning observations of successive groups are represented by an empirical formula.

The figures in the columns headed 1, 2, 3, 4 are taken from the Tables 3, 4, 7, 10 respectively of Carnera's discussion.

The last four columns give the differences $(1-2)$, $(1-3)$, $(1-4)$, $(3-4)$. It will be noticed that the differences $(1-2)$ are large and have a range more than half that of the range of the values under (1). On the other hand the differences $(1-3)$ are small (with the exception of the values for 1936·22) and indicate that the southern stations are in general agreement with the northern. The differences $(1-4)$ and $(3-4)$ are, on the whole, rather larger and more systematic in character than the $(1-3)$ differences.

Values of x (Unit 0″·001)

Fraction of year	1	2	3	4	1−2	1−3	1−4	3−4
·06	−124	− 69	−137	−145	−55	+13	+21	+ 8
·14	− 91	− 88	− 80	− 86	− 3	−11	− 5	+ 6
·22	−115	−149	− 85	− 89	+34	−30	−26	+ 4
·31	− 48	− 19	− 45	− 40	−29	− 3	− 8	− 5
·39	− 10	− 43	− 6	− 4	+33	− 4	− 6	− 2
·48	+ 60	+ 90	+ 54	+ 65	−30	+ 6	− 5	−11
·56	+ 62	+ 65	+ 52	+ 54	− 3	+10	+ 8	− 2
·64	+ 36	+ 71	+ 40	+ 47	−35	− 4	−11	− 7
·72	− 32	− 8	− 28	− 26	−24	− 4	− 6	− 2
·81	− 46	− 35	− 55	− 47	−11	+ 9	+ 1	− 8
·89	− 82	−119	− 86	− 90	+37	+ 4	+ 8	+ 4
·97	−126	−175	−138	−143	+49	+12	+17	+ 5

Values of y (Unit 0″·001)

Fraction of year	1	2	3	4	1−2	1−3	1−4	3−4
·06	+ 78	+ 91	+ 68	+74	−13	+10	+ 4	− 6
·14	+ 90	+101	+ 99	+96	−11	− 9	− 6	+ 3
·22	+ 81	+ 25	+106	+98	+56	−25	−17	+ 8
·31	+ 99	+ 72	+102	+90	+27	− 3	+ 9	+12
·39	+104	+ 90	+107	+97	+14	− 3	+ 7	+10
·48	+ 85	+ 60	+ 83	+73	+25	+ 2	+12	+10
·56	+ 60	+ 56	+ 52	+53	+ 4	+ 8	+ 7	− 1
·64	+ 20	+ 39	+ 23	+24	−19	− 3	− 4	− 1
·72	− 22	+ 22	− 20	−13	−44	− 2	− 9	− 7
·81	− 15	+ 18	− 17	− 4	−33	+ 2	−11	−13
·89	− 47	− 9	− 49	−37	−38	+ 2	−10	−12
·97	+ 41	+ 61	+ 30	+40	−20	+11	+ 1	−10

It appears that the best provisional values for x and y are those given under (3), derived from the combination of northern and southern stations without the use of empirical formulae, and that the introduction of these empirical formulae has impaired the results.

Let us suppose, however, that there is some theoretical justification for the inclusion of a term $f(\odot, \alpha)$, a function of the longitude of the Sun and of the right ascensions of the observed stars, in the equation (1) above. As the latitude variations, the corrections to the mean declinations of each group, and the term $f(\odot, \alpha)$ are tangled up with each other, the only effective way of disentangling them is by least squares adjustment. Assume the form of $f(\odot, \alpha)$ to be known, e.g.

$$a \cos(m\odot - n\alpha) + b \sin(m\odot - n\alpha),$$

but not the coefficients a and b. Then we can determine each value of x and y, and each group correction in declination, in terms of a and b. By substituting back in equation (1), a series of equations involving a and b are obtained, from which we might hope to obtain a and b by least squares solution or, in other words, to derive the amplitude and phase angle of $f(\odot, \alpha)$.

This procedure was tried in the discussion of the results obtained with the Cookson floating zenith telescope at Greenwich (Spencer Jones, *M.N., R.A.S.* **96**, 122, 1935). The programme with this telescope is more favourable for the disentangling of these effects than the International programme, because two interlacing Küstner polygons are involved. It was found that the coefficients of the a and b terms, when the substitution mentioned above was made, were in general so small that the coefficients a and b were practically indeterminate. The exception was in the case of terms of the form sin $(\odot-\alpha)$ and sin 2 $(\odot-\alpha)$. Such terms in the International programme merely give rise to a constant difference between evening and morning observations.

Thus, though a term of e.g. the form $a \sin(2\odot-\alpha)+b\cos(2\odot-\alpha)$ may be assumed (as e.g. in the methods of reduction used by Kimura) and the effect on the latitude variation can be deduced, such a term cannot be derived with any accuracy from the observations. The coefficients a and b are determined with such low weight that the effect on the latitude variation may be entirely spurious. The method used by Kimura seems moreover to neglect the effect on the group corrections, which is not permissible.

This discussion supports the conclusion that the best provisional values of x and y to be used for 1936 are those given in Table 7 of Carnera's paper (*Ast. Nach.* No. 6290), under the headings X, Y.

(c) *From Dr H. Kimura, International Latitude Observatory, Mizusawa*

I have the pleasure to report about the progress in the preparation for publication of Vol. **8** of the *Results of the International Latitude Service during* 1922·7–1936·0.

Since the summer of last year I have been incessantly working on the investigation of all the observations in the north and south parallels during the above period. However, it is yet too early to come to a final decision about the most suitable formula for easy calculation by computers, because some unexpected but very interesting systematics have been found one after another; as these are closely related to one another the elaborate calculations must be repeated several times. For such reasons, the time of completing the whole work cannot yet be estimated.

(d) *From Dr H. Spencer Jones, Royal Observatory, Greenwich*

The derivation, recently completed, of the constant of nutation from twenty-five years' observations with the Cookson floating zenith telescope at Greenwich, has suggested that the large amount of material now available in the observations that have been made at the International Latitude Stations since 1900 should be discussed for the determination of the constant of nutation.

The observations made at Mizusawa, Carloforte, Gaithersburg, Cincinnati and Ukiah in the years 1900 to 1915 were used by Przybyllok for the derivation of the constant of nutation (*Zentralbureau der Int. Erdmessung Veröff.* Neue Folge, No. 36, 1920). The discussion was limited to fifteen years, which is not a full nutation period, because observations at Gaithersburg were discontinued in 1915 and those at Cincinnati were discontinued in 1916.

Observations have been made at Mizusawa, Carloforte and Ukiah continuously since 1900. Changes were made in the star-pairs under observation in 1906, 1912 and 1922. The observed latitudes have been published up to 1931·0. The observations from 1931·0 to 1936·0 are in course of preparation for publication.

The following material is now available for the determination of the constant of nutation:

26 pairs	have been	observed	from	1900 to 1931
21	,,	,,	,,	1906 to 1931
13	,,	,,	,,	1912 to 1931
27	,,	,,	,,	1900 to 1922
6	,,	,,	,,	1906 to 1922.

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There were no further changes in the programme until 1935, so that the observations from 1931 to 1935 can probably be incorporated.

It is intended to discuss this material for the three stations Mizusawa, Carloforte and Ukiah, at the Royal Observatory, Greenwich. The nutation constant is related to the mass of the Moon, and an improved value for this mass is being derived at Greenwich from the observations of the minor planet Eros made at a number of observatories at the opposition of 1930–31.

(e) *From Dr Harlan T. Stetson, Massachusetts Institute of Technology*

The question of small periodic or secular changes in geographical co-ordinates involves a careful and systematic study of apparent variations in both latitude and longitude. From this point of view it will be seen that the work of Commissions 18 and 19 is very closely allied.

Studies of the possible connection between positions of the moon and variations in both latitude and longitude have been continued by me. The apparent variation in longitude with the moon's position reported previously in the Royal Astronomical Society (*Monthly Notices*, **93**, 1933, and **95**, 1935) by A. L. Loomis and myself now appears to have been partly explained by the seasonal variation which we mentioned in the second paper exhibited. Mr Kawasaki has called attention to this as a possible explanation of variation of longitude with the moon's declination. The recently published note on "An Annual Change in Longitudes", by Prof. Schlesinger (*Monthly Notices*, **97**, No. 9, 1937) very happily shows that this small change may be largely explained as due to the motion of the pole during the years covered by our investigation. The question of residual variations still outstanding and also the reason for the seasonal change, however, is still open.

In the results of my own studies of the variation of latitude with the moon's position, it is a little difficult to be satisfied that a seasonal variation remains that could account for the observed correspondence between small latitude changes and the hour angle and declination of the moon. It is to be emphasized that in the treatment of the original observations corrections were first made for the known motion of the pole which should have included the 365-day and 428-day periods. Taking this into consideration the residuals remaining would appear to be independent of a seasonal variation.

From an analysis of the latitude observations 1928–31, Mr Kawasaki and I have both found independently that the residual variations which appear to correlate with the moon's position for these three years is less than half of that previously found by me from earlier series of latitude observations. It appears that any variation such as may correlate with the moon may be more apparent during certain years than others. My findings for the years 1909, 1910, and 1911 (*Nature*, **123**, 127, 1929) would appear reasonably consistent with those of Schumann,* who in 1906 called attention to a lunar term of $0''\cdot03$ dependent upon the moon's hour angle and not upon twice the lunar hour angle.

In view of the possible geophysical significance of observations, I should like to suggest that the Commission again give consideration to the question of how declinations of the stars should best be adjusted to satisfy the several stations of the International Latitude Service. In discussing the results of Vol. **7** of the Inter-

* *Ergänzungshefte zu den Astronomischen Nachrichten*, Nr. 11.

national Latitude Service, Mr Kimura calls attention to the fact that if the declinations of the stars are to be adjusted from the measures of latitude therein contained, a correction of $+0''.11$ is needed. It is obvious that if we entertain the question of possible local shifts in the position of observatories, then the adjustment of declinations to procure the best fit for all the stations may obscure the very thing which would be of most concern.

For reasons admirably set forth in Prof. Schlesinger's paper, it would appear desirable that studies of variation of latitude with the moon's position be confined to the examination of each year's series of observations separately. It seems possible that a rigid harmonic analysis of many years of latitude determinations may not be fruitful in isolating the effect sought, if such exists.

(*f*) *Proposal from Dr Kimura for change of programme at International Latitude Stations, with remarks by Dr H. Spencer Jones*

The proposal has been received from Dr Kimura that the star programme for the international north and south parallels should be as shown below.

The advantage of this programme, as stated by Dr Kimura, is that each of the two principal terms of z, viz. $a \sin(\odot-\alpha+A)+b\sin(2\odot-\alpha+B)$ and the declination errors $\Delta\delta$ may be found from the observed materials of each station quite independently of those of the other stations, which is impossible under the present programme. The disadvantage is that the shortness of the duration of the observations in a combination will decrease the accuracy of the group mean. The derivation of the terms in z is explained by Dr Kimura in a paper published in *Proc. Imp. Acad. Tokyo*, **14**, 102, 1938.

Star programme		Observing programme	
Group	Limits of R.A.	Date	Groups
I	$0^h.0$– $1^h.5$	Dec. 20–Jan. 12	V, VI, VII
II	1 ·5– 3 ·0	Jan. 13–Feb. 4	VI, VII, VIII
III	3 ·0– 4 ·5	Feb. 5–Feb. 26	VII, VIII, IX
IV	4 ·5– 6 ·0	Feb. 27–March 21	VIII, IX, X
V	6 ·0– 7 ·5	March 22–April 13	IX, X, XI
VI	7 ·5– 9 ·0	April 14–May 6	X, XI, XII
VII	9 ·0–10 ·5	May 7–May 29	XI, XII, XIII
VIII	10 ·5–12 ·0	May 30–June 20	XII, XIII, XIV
IX	12 ·0–13 ·5	June 21–July 13	XIII, XIV, XV
X	13 ·5–15 ·0	July 14–Aug. 5	XIV, XV, XVI
XI	15 ·0–16 ·5	Aug. 6–Aug. 27	XV, XVI, I
XII	16 ·5–18 ·0	Aug. 28–Sept. 19	XVI, I, II
XIII	18 ·0–19 ·5	Sept. 20–Oct. 12	I, II, III
XIV	19 ·5–21 ·0	Oct. 13–Nov. 4	II, III, IV
XV	21 ·0–22 ·5	Nov. 5–Nov. 27	III, IV, V
XVI	22 ·5– 0 ·0	Nov. 28–Dec. 19	IV, V, VI

I have looked into the question of the accuracy with which a term of the form $b\sin(2\odot-\alpha+B)$ can be determined from such a programme. This term can be written in the form $s\sin(2\odot-\alpha)+c\cos(2\odot-\alpha)$. For each group and period we have an equation of the form

$$t_p+z_q+s\sin(2\odot-\alpha)+c\cos(2\odot-\alpha)=\phi-\phi_0,$$

where t_p is the latitude variation in the *p*th period and z_q is the correction to the declinations of the *q*th group. Normal equations can be formed for the *t*'s and the *z*'s and solved. Assuming even weight for each group in each period, the following values for the portions of the *t*'s and *z*'s depending on *s* and *c* are obtained:

z_1	$=+0{\cdot}54s-0{\cdot}81c$		t_1	$=+1{\cdot}84s+0{\cdot}37c$	
z_2	$=+\ {\cdot}19$	$-\ {\cdot}96$	t_2	$=+1{\cdot}84$	$-\ {\cdot}37$
z_3	$=-\ {\cdot}19$	$-\ {\cdot}96$	t_3	$=+1{\cdot}56$	$-1{\cdot}04$
z_4	$=-\ {\cdot}54$	$-\ {\cdot}81$	t_4	$=+1{\cdot}04$	$-1{\cdot}56$
z_5	$=-\ {\cdot}81$	$-\ {\cdot}54$	t_5	$=+\ {\cdot}37$	$-1{\cdot}84$
z_6	$=-\ {\cdot}96$	$-\ {\cdot}19$	t_6	$=-\ {\cdot}37$	$-1{\cdot}84$
z_7	$=-\ {\cdot}96$	$+\ {\cdot}19$	t_7	$=-1{\cdot}04$	$-1{\cdot}56$
z_8	$=-\ {\cdot}81$	$-\ {\cdot}54$	t_8	$=-1{\cdot}56$	$-1{\cdot}04$
z_9	$=-\ {\cdot}54$	$+\ {\cdot}81$	t_9	$=-1{\cdot}84$	$-\ {\cdot}37$
z_{10}	$=-\ {\cdot}19$	$+\ {\cdot}96$	t_{10}	$=-1{\cdot}84$	$+\ {\cdot}37$
z_{11}	$=+\ {\cdot}19$	$+\ {\cdot}96$	t_{11}	$=-1{\cdot}56$	$+1{\cdot}04$
z_{12}	$=+\ {\cdot}54$	$+\ {\cdot}81$	t_{12}	$=-1{\cdot}04$	$+1{\cdot}56$
z_{13}	$=+\ {\cdot}81$	$+\ {\cdot}54$	t_{13}	$=-\ {\cdot}37$	$+1{\cdot}84$
z_{14}	$=+\ {\cdot}96$	$+\ {\cdot}19$	t_{14}	$=+\ {\cdot}37$	$+1{\cdot}84$
z_{15}	$=+\ {\cdot}96$	$-\ {\cdot}19$	t_{15}	$=+1{\cdot}04$	$+1{\cdot}56$
z_{16}	$=+\ {\cdot}81$	$-\ {\cdot}54$	t_{16}	$=+1{\cdot}56$	$+1{\cdot}04$

On substituting the *t*'s and *z*'s in the original equations of correction, equations involving *s* and *c* are obtained from which *s* and *c* are to be deduced. The coefficients of both *s* and *c* are small, however, and in no case exceed 0·10.

If 50 pairs are observed for each period, in each of the three groups, giving a total of 2400 pairs in one year at one station, the total weight of the determination of *s* and *c* is found to be 6; unit weight, corresponding to the observation of one pair, has a mean error of $\pm 0''{\cdot}30$. The mean error of the derived values of *s* and *c* would therefore be $\pm 0''{\cdot}12$. In general, the uneven distribution of the observations throughout the year will increase this probable error.

Thus, under particularly favourable conditions, many years' observations would be required to derive the term in $(2\odot-\alpha)$ with a probable error smaller than the term itself. It will be noticed, moreover, that both the *s* and *c* terms have an effect on the latitude variation in the form of an annual term, with considerable amplitude.

The conclusion is that, in any such programme, it is important that a term of the form $b \sin(2\odot-\alpha+B)$ should not be deduced from the observations of one or two years. The determination will be very weak and the effect on the deduced latitude variation may be considerable.

H. Spencer Jones
President of the Commission

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