Ross type, but suitable for usual observations. The members of the Commission on examining the drawings thought the design a good one and wished to have a similar instrument at every station. Attention was called, however, to the small field of view, which cuts down sharply the number of available bright stars and necessitates the observation of faint stars, whose proper motions were not accurately known.

The Chairman called attention to the fact that uniformity of instruments and methods was an essential feature of the International Latitude Service and that unless all the co-operating governments would be prepared to bear the cost of new instruments of the Carnera type it would not be possible to adopt a new design of zenith telescope. Furthermore the design would need to be thoroughly tested at one station before its general adoption could be recommended. Prof. Carnera asked whether the Union could contribute towards the expense of an experimental instrument, stating that the approval of the Union and some financial support would be a help in obtaining further funds. The Chairman felt, however, that the Union had no money available for such a purpose. The Commission therefore recommended that Prof. Carnera should try whether he could secure funds for such an instrument, the cost of which was estimated at RM. 10,000. The success of such an instrument would help in securing its general introduction into the work of the Latitude Service.

The Commission then adjourned.

COMMISSION 20 (MINOR PLANETS, COMETS AND SATELLITES)

PRESIDENT: Prof. A. O. LEUSCHNER.
SECRETARY: Miss J. M. VINTER HANSEN.

1. Joint meeting of Commissions 4, 8 and 20 on August 4.

This meeting is recorded in the report of Commission 4 (see p. 355).

2. Meeting on August 5.

The President mentioned the resolutions adopted on the previous day at the joint meeting of Commissions 4, 8 and 20. As Commission 20 was adequately represented at that meeting these resolutions needed no further discussion in Commission 20.

The President also mentioned a proposal by Prof. Kepiński that the national ephemerides should supply barycentric corrections to the Sun's geocentric rectangular co-ordinates. This proposal was referred to Commission 4.

The President supplemented the report of the sub-commission on solar parallax (see p. 150) with some communications that had come to hand after the printing of the Draft Report; for instance Prof. Slocum of the Van Vleck Observatory had written that the cause of his Eros observations in 1931 not having been reduced immediately was lack of accurate positions for some of his comparison stars. Also Prof. Trumpler had published (*L. O. Bull.* **18**, 93, 1937) the results, based on Kopff's Catalogue of primary reference stars, obtained with the 15-foot camera of the Lick Observatory. Prof. Hagihara was glad to be able to inform the Commission that Mr Hasimoto had now measured the plates of the Eros observations taken in Tokyo. The report on solar parallax was adopted.

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The Secretary of the sub-commission on periodic comets, Miss Vinter Hansen, reported as follows:

Sub-commission on Periodic Comets

At the Paris meeting of the International Astronomical Union in 1935 a sub-commission of Commission 20 was appointed to arrange for the calculation of orbits and ephemerides of short-period comets so as to avoid—as far as possible—duplication of work. The President of this sub-commission is Dr A. C. D. Crommelin and Miss J. M. Vinter Hansen has been acting as Secretary.

Hitherto information about cometary work was obtained through reports and notes published more or less regularly in different journals. Special mention should be made of the useful work done in this direction by Prof. H. Kobold of Kiel, and by Dr Crommelin of London. Besides the comet notes published in the *Astronomische Nachrichten* and in the *Beobachtungs-Zirkulare* Kobold publishes a report every year in the *Vierteljahrsschrift der Astronomischen Gesellschaft* on all apparitions of comets in the preceding year, giving a description of their appearance and a list of observations and orbits. Also for many years he has kept a file of all persons engaged in cometary calculations, thus providing an invaluable source of information; we are deeply indebted to him for much useful knowledge. In *Astronomische Nachrichten* No. 6226 he has given a synopsis of the work on cometary orbits.

Crommelin publishes comet notes in *The Observatory* and the *Journal of the British Astronomical Association* and also every year in the *Monthly Notices of the Royal Astronomical Society* gives a synopsis, with a table of elements, of cometary orbits published in the preceding year. His comet catalogue in the *Memoirs of the B.A.A.*, vols. **26** and **30**, is a continuation of Galle's renowned work *Cometenbahnen*. Through the B.A.A. Crommelin organizes computations of orbits and ephemerides for those short-period comets whose perihelion passages are approaching, in cases where no other arrangements for computation have been made. The results appear in the *Handbook of the B.A.A.*

Various notes about comets appear in different circulars (such as those from the I.A.U. Central Bureau for Astronomical Telegrams and the *Harvard Announcement Cards*) and in many journals; for instance Prof. G. van Biesbroeck, to whom many discoveries and rediscoveries of comets are due, regularly publishes comet notes in *Popular Astronomy*. In 1936 Prof. I. Yamamoto of the Kwasan Observatory published a *Preliminary General Catalogue of Comets* in which he gives the elements of 467 comets together with a list of 37 short-period comets and another list of 48 uncertain comets.

The work of our sub-commission has progressed along the following lines. After we had published a notice about the appointment of the sub-commission in the *Circulars of the I.A.U. Bureau for Astronomical Telegrams*, the *Harvard Announcement Cards*, the *Astronomische Nachrichten*, and the *Journal of the B.A.A.*, we received a number of letters from astronomers who were already engaged in cometary calculations or who wished to start work on some special comet. In each case we had to ascertain whether such work was already being done by other astronomers; if not, a reservation was published through the four above-mentioned periodicals. We also received many letters asking for guidance concerning the selection of suitable comets for calculation, and so were able to get work started on some short-period comets whose orbits were badly in need of revision. The orbits of those comets that were approaching perihelion, and for which no computers came forward, were taken in hand by the Computing Section of the B.A.A.

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List of short-period comets for which reservations have been made through the sub-commission:

Name of comet	Period y	Last apparition	Next apparition	Computer
Tuttle-Giacobini	?	1907	?	B.A.A., Stephens
Tempel II	5·2	1930	1941	Ramensky
Neujmin II	5·4	1927	1943	Neujmin
Schwassmann-Wachmann III	5·4	1930	1941	Parfenow
Pons-Winnecke	6·2	1933	1939	(Guth), Sumner
Schwassmann-Wachmann II	6·4	1935	1941	Rasmusen
Forbes	6·4	1929	1942	Makarow
d'Arrest	6·6	1923	1943	Recht
Kopff	6·6	1932	1939	Kepiński
Daniel	6·8	1937	1944	Hirose
Finlay	6·9	1926	1940	Cimmino
Reinmuth	7·2	1935	1942	Kanda
Faye	7·3	1933	1940	Zseverzsev
Wolf II	7·5	1924	1940	Kanda
Schaumasse	8·0	1927	1943	Kanda
Jackson-Neujmin	8·–	1936	1944	Cunningham
Comas y Solá	8·5	1935	1944	Vinter Hansen
1889 VI	8·9 (?)	1889	?	Stephens
Gale	11·0	1938	1949	(Sumner), (Cripps), Cunningham
Schwassmann-Wachmann I	16·3	Obs. every year		Behrens, Cunningham
Pons-Coggia-Winnecke-Forbes	27·9	1928	1956	Crommelin
Olbers	72·7	1887	1960	Rasmusen
Halley	76·0	1910	1986	Bobone

Other short-period comets and computers of their orbits:

Comet	Computer
Encke	Observatory Pulkovo
Tuttle I	Crommelin
Tempel I	v. Schrutka-Rechtenstamm
Wolf I	Kamieński
Neujmin I	van Biesbroeck
Giacobini-Zinner	Cripps
de Vico-Swift	(Seares)

No information is at hand about the calculation of predictions for the following periodic comets:

Comet	Period y	Last apparition
Grigg-Skjellerup	5·0	1937
Brorsen	5·4	1879
Tempel-Swift	5·9	1908
Perrine I	6·5	1909
Biela	6·6	1852
Borrelly	6·9	1932
Brooks II	6·9	1932
Holmes	7·–	1906
Westphal	61·7	1913
Brorsen-Metcalf	69·1	1919
Pons-Brooks	71·6	1884

The orbits of some of the older comets are badly in need of a thorough examination and of the calculation of perturbations up to the present time to secure the rediscovery of the comets.

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The Secretary supplemented the report with the information that Dr Crommelin had announced that the *B.A.A. Handbook* for 1939 would provide ephemerides for comets Borrelly and Brooks II, which are among the comets that are not otherwise provided for. As regards the other comets in list 3 of the report the comets Biela, Brorsen and Holmes are doubtful cases, and it seems improbable that they will ever be found again through prediction. The report was adopted without further discussion.

In connection with the recommendation from the Paris meeting (*Trans. I.A.U.* **5**, 310) that the elements of the major planets be corrected, the President reported that Dr Brouwer, of Yale Observatory, together with Dr Eckert of Columbia University has undertaken new elements and general perturbations for Uranus and Neptune. Dr Eckert also, through his Hollerith computing bureau, had checked Brown's lunar theory. He and his workers had used more than 250,000 punched cards and six automatic computing machines, and in two years had been able to accomplish work that originally required 30 years of manual calculation. The mathematics of checking the lunar theory consists of substituting into differential equations the harmonic series which represent the co-ordinates. The series expression for each co-ordinate contains about 500 terms with coefficients of ten significant figures. The principal part of the machine computation consists in multiplying such series (of 500 terms each) together in pairs. It was found that Brown's original work was correct to within 0″·01, which is the degree of accuracy originally desired for the lunar theory. The President expressed his pleasure that Prof. Brown had had this splendid confirmation of his theory before his death.

The President stated in connection with the resolution passed by the General Assembly at the Paris meeting in 1935 about the calculation and publication of accurate ephemerides of the first four minor planets that this has been taken in hand by the Rechen-Institut, which now publishes the ephemerides in *Kleine Planeten*, based on new elements for 1 Ceres by G. Stracke, 2 Pallas by A. Kahrstedt, 3 Juno by F. Gondolatsch, while for 4 Vesta B. F. Bawtree is continuing the ephemerides on the basis of the general perturbations by Leveau.

The President regretted to say that no steps had been taken to approach the President of Commission 5 regarding the question of a "complete historical record of all changes that have been made in the almanacs since their inception, particularly as regards tables of the Sun and major planets and astronomical constants" (*Trans. I.A.U.* **5**, 310), but hoped that at the next meeting of the Union progress would have been made in this direction.

It was announced that MM. Fayet, Dusl and Banachiewicz wished to address the Commission at its next session.

The President put the following proposal to the members of the Commission for their consideration: "In view of the inconclusive character of available studies of libration, periodic solutions, convergence of general theories, structure of gaps for certain groups or individual cases of minor planets, the Commission emphasizes the importance of basing such studies hereafter on dependable mean elements, particularly mean mean motions, instead of on osculating or approximate elements."

3. Meeting on August 9.

The President mentioned the reports he had received from institutes and various members of the Commission; it was agreed that extracts be included in this report.

As regards the *Research Surveys of Minor Planets* (*Publ. Lick Obs.* **19**, 1935), the President stated that this work was being continued, and that assistance for its continuation is being supplied by the Works Progress Administration (W.P.A.) of the U.S.A. Prof. Strömgren expressed his satisfaction at this news and moved the following resolution to go before the General Assembly: "The Union recommends the continuation of Prof. Leuschner's *Research Surveys of Minor Planets*, which are very helpful and are characterized by their high standard of reliability." The motion was carried unanimously.

The President invited the members to express their opinion upon his proposal on libration, etc., put forward at the end of the previous meeting. Prof. Heinrich was very grateful that the President had raised this interesting question and completely agreed with him. He pointed out that many authors had been misled in their reasoning through inaccurate mean motions as a small change in mean motion might produce a great change in the whole orbit. For practical purposes many of the existing orbits for minor planets are satisfactory for 50–80 years, but beyond that time it might be dangerous to draw theoretical conclusions from the material available. In most cases our observations are not sufficiently extended to enable us to decide definitely between libration and rotation of the perihelion. So all theoretical workers should be advised to give up exact conclusions upon that matter or else give their conclusions with all possible reserve and base them upon reliable mean elements. The case of the satellites seems a little better; very accurate observations have been available for about 40 years, but this corresponds to more than twenty centuries in the system of the inner planets. The suggestion would therefore be to impress on observers the necessity of procuring the most careful observations of minor planets and satellites using powerful American instruments. The President suggested that his proposal be put on the agenda for the next meeting, which met with approval.

Prof. Dusl made the following remarks on the integration of Hill's differential equation:

"On cherche seulement des solutions périodiques en utilisant les méthodes, qui se rapprochent aux équations intégrales et à l'espace de Hilbert. On établit des conditions nécessaires et suffisantes pour que le vecteur inconnu, qu'on a introduit, soit unique et appartienne à l'espace de Hilbert."

The President called upon Prof. Fayet, who made the following statement about his studies on proximities of orbits for minor planets and periodic comets:

"Cette étude a porté principalement sur les 800 astéroïdes pour lesquels j'ai publié des tables.*

Pour la première approximation, j'ai fait usage d'une méthode graphique: sur du papier à décalquer, on a tracé, pour chacune des planètes considérées, la courbe fermée, lieu des intersections de l'orbite avec un plan mobile, perpendiculaire à l'écliptique et effectuant une révolution complète autour d'un axe passant par le Soleil et perpendiculaire au plan de l'écliptique.

La superposition des graphiques correspondants à deux astres renseigne alors d'une manière rapide sur la région (ou les régions) où les 2 orbites se rapprochent à une distance mutuelle minima. En adoptant, pour le tracé des courbes, l'échelle de 10 cm. pour le rayon moyen de l'orbite terrestre, ce procédé m'a fourni aisément la longitude héliocentrique de la proximité à $\frac{1}{2}$ degré près et la valeur de la distance minima ρ_m à 0·005 près. Ce travail, qui comporte 319,600 comparaisons de deux graphiques, est terminé depuis déjà plusieurs mois et le résultat n'a pas été sans me surprendre, car le nombre des cas qui paraissent mériter un examen plus minutieux

* *Petites planètes. Tables de coordonnées héliocentriques et données concernant les oppositions* (2 vols. Paris, 1932 et 1933).

(on a regardé comme tels ceux qui révèlent une valeur de ρ_m inférieure à 0·015) est apparu beaucoup plus notable que je ne l'avais prévu: il dépasse 12,000.

Malgré le labeur considérable qu'entraînera l'étude plus précise d'un aussi grand nombre de cas, j'ai entrepris, par le calcul, pour chacun de ces groupes, les recherches suivantes:

(*a*) Détermination, à 0°·1 près, de la longitude héliocentrique de la région de proximité.

(*b*) Détermination, à 0·001 près, de la valeur de la distance minima ρ_m.

(*c*) Détermination des époques éventuelles (en se limitant provisoirement à l'intervalle 1855–1980) où les deux astres peuvent se rapprocher assez près pour que leur action perturbatrice mutuelle cesse d'être négligeable.

Dans le cours de cette étude j'ai été amené à envisager d'autres questions connexes, parmi lesquelles je me contente de citer:

— Etude de la répartition des quelque 12,000 points de proximité mis en évidence.

— Recherche de proximités intéressant simultanément plus de deux orbites d'astéroïdes.

J'espère que l'ensemble de ces calculs sera achevé pour la fin de 1939.

D'autre part, ayant construit également des tables de coordonnées héliocentriques pour une centaine d'orbites concernant les comètes à courte ou moyenne période (*P* inférieur à 80 ans), j'ai entrepris, pour ces astres, une étude identique à celle poursuivie pour les petites planètes, ce qui m'a conduit à envisager successivement les proximités:

(1°) de ces orbites cométaires avec celles des grosses planètes,

(2°) de ces orbites cométaires entre elles,

(3°) de ces orbites cométaires avec celles de 138 astéroïdes dont le diamètre surpasse 60 km.

J'y ai joint naturellement la recherche des époques éventuelles de rapprochement effectif. Ce travail est à peu près terminé et les principaux résultats en seront publiés prochainement."

Prof. Banachiewicz, who was to have given an exposition of the new technique he has introduced for solving the normal equations of the method of least squares, was only able to deliver a short explanation as he had to attend a meeting of the Executive Committee. His remarks in their original form were as follows:

"La nouvelle technique repose sur trois fondements. D'abord, sur le théorème général relatif à la vérification d'un produit de deux cracoviens (*C.R. Ac. Pol.* Jan. 1938). Ce théorème donne un contrôle particulier pour chaque ligne et chaque colonne du produit, et en outre un contrôle général, le plus utile pour un calculateur exercé, embrassant tous les éléments du produit. Ensuite, c'est l'emploi des cracoviens qui permet de réduire au minimum la description des opérations à effectuer et qui rend les calculs faciles et peu fatigants (les épreuves des *Acta Astronomica* d'un exemple numérique ont été distribuées entre les personnes présentes). Toutefois, pour faire valoir pleinement ces propriétés générales des cracoviens, il a fallu d'établir encore le troisième fondement: le fait que le tableau cherché des coefficients des erreurs moyennes (l'inverse du tableau des coefficients des équations normales) est un carré, en sens du calcul de cracoviens, de l'inverse, facile à obtenir, de la racine carrée la plus simple du tableau des coefficients des équations normales, c'est donc à la recherche de cette racine carrée canonique que se réduit le problème (*Bull. Ac. Sc. Polon.* mars 1938). Une pareille interprétation des calculs conduit d'ailleurs à maintes conséquences théoriques."

Prof. Hagihara moved the following advisory resolution which was seconded by Dr Comrie and carried unanimously:

"Commission 20 asks observers to observe with special care the positions of the minor planets of the so-called critical types, such as the Hecuba group, Hilda group, Hestia group, Thule group, etc., etc., so as to enable the theoretical workers to study their motions."

Prof. Kepiński once more drew the attention of the Commission to the question of the barycentric co-ordinates of the Sun. His remarks on this subject were in their original form as follows:

"Les annuaires astronomiques contiennent, comme l'on sait, les coordonnées géocentriques du Soleil X_g, Y_g, Z_g. Il va sans dire qu'elles portent l'influence du mouvement de la Lune de la période d'un mois synodique. Ce fait pèse d'une façon assez pénible sur le calculateur qui se propose d'établir l'éphéméride exacte d'une planète ou d'une comète à des intervalles espacés, de 8 jours p.e. que l'on resserre ensuite à l'aide d'une interpolation.

Vu donc que les calculs d'une éphéméride, basée sur les perturbations causées par plusieurs grandes planètes, présentent, par ce seul fait, certaines difficultés, il est tout naturel que l'on soit tenté de recourir à chaque simplification possible et en voici une que je propose: de donner dans les annuaires, à côté des coordonnées géocentriques, la réduction barycentrique du Soleil dX, dY, dZ, dans l'intervalle de 12 heures, ce qui permettrait facilement de passer aux coordonnées barycentriques. Dans ce but on pourrait se servir des formules suivantes:

$$X_b = X_g - dX, \quad dX = [3{\cdot}7139{-}10] \operatorname{cosec} \pi_☾ \cos \beta_☾ \cos \lambda_☾$$
$$[\qquad\qquad] \operatorname{cosec} \pi_☾ \cos \delta_☾ \cos \alpha_☾$$
$$Y_b = Y_g - dY, \quad dY = [3{\cdot}7139{-}10] \operatorname{cosec} \pi_☾ \cos \beta_☾ (\cos \epsilon \sin \lambda_☾ - \sin \epsilon\, tg\, \beta_☾)$$
$$[\qquad\qquad] \operatorname{cosec} \pi_☾ \cos \delta_☾ \sin \alpha_☾$$
$$Z_b = Z_g - dZ, \quad dZ = [3{\cdot}7139{-}10] \operatorname{cosec} \pi_☾ \cos \beta_☾ (\sin \epsilon \sin \lambda_☾ + \cos \epsilon\, tg\, \beta_☾)$$
$$[\qquad\qquad] \operatorname{cosec} \pi_☾ \sin \delta_☾.$$

L'avantage de cet arrangement consisterait alors en ce que les différences des X, Y, Z ainsi que des α, δ présenteraient une marche assez régulière ce qui serait favorable au processus de l'interpolation, contrairement au cas actuel qui oblige de recourir aux différences des quantités X_g, Y_g, Z_g, α_g, δ_g dont la marche est très irrégulière dans les intervalles quelque peu distants.

Pour en revenir aux quantités α_g, δ_g, on pourrait tenir compte des formules suivantes:

$$\Delta \cos \delta\, d\alpha = -\sin \alpha\, dX + \cos \alpha\, dY$$
$$\Delta\, d\delta = -\sin \delta \cos \alpha\, dX - \sin \delta \sin \alpha\, dY + \cos \delta\, dZ$$
$$d\Delta = \cos \delta \cos \alpha\, dX + \cos \delta \sin \alpha\, dY + \sin \delta\, dZ."$$

Dr Comrie read the recommendation of Commission 4 (p. 360) endorsing the planned publication of the Sun's barycentric co-ordinates in the Cracow Almanac. No further action was thought necessary.

At the end of the session Prof. Fayet moved the following vote of thanks, which was carried unanimously:

"En adressant à M. le professeur Leuschner toute leur gratitude pour la haute compétence, le dévouement et la remarquable activité avec lesquels il a dirigé la Commission 20, les membres de cette Commission sont particulièrement heureux d'adresser à M. le professeur Leuschner leurs vives félicitations pour sa désignation comme Président d'Honneur de leur Commission."

Astronomisches Rechen-Institut. Dr G. Stracke writes:

"Über die Tätigkeit der Planetenabteilung des Astronomischen Rechen-Instituts an den Kleinen Planeten geben die Veröffentlichungen in *A.N.* **258**, 65, **261**, 329, **264**, 281, unsere R.-I.-Zirkulare, unsere Jahrbücher, *Kleine Planeten*, Jahrgang 1936, 1937, 1938 und die Jahresberichte von Prof. Kopff in der *Vierteljahrsschrift der Astronomischen Gesellschaft* Auskunft.—Die Bearbeitung der Bahnen der numerierten Planeten ist soweit fortgeschritten, dass stärkere Abweichungen als 4^m in der letzten beobachteten Opposition augenblicklich nur noch 7 Planeten (410, 592, 998, 1166, 1220, 1262, 1327) haben. Die übrigen 1426 numerierten Planeten sind, soweit es das Beobachtungsmaterial zulässt, so gesichert, dass sie der Bedingungen unseres Programms entsprechen. Wir haben inzwischen damit begonnen, für eine Reihe von gesicherten Planeten genäherte spezielle Störungen bis zum Ende des Jahres 1945 voraus zu berechnen. Wir bevorzugen dabei Planeten mit starken Störungen. Für diese Planeten werden zukünftig in jeder Opposition gestörte Ephemeriden gegeben werden.—Für den Planeten 887 Alinda habe ich die genaue Bearbeitung mit Berücksichtigung der Störungen durch alle 8 Grossen Planeten bis zur Opp. 1938 fortgesetzt und eine genaue Ephemeride gegeben. Der Planet ist in Bergedorf, Heidelberg, Yerkes und Mt. Wilson beobachtet worden.—Im Druck habe ich eine Arbeit: 'Identifizierungsnachweis der Kleinen Planeten, 1. 1. 1801–1. 4. 1938.' Die Druckanordnung ist die gleiche wie in *V.R.I.* no. 45. Sie wird im Sept. 1938 in den *Abhandlungen der Preuss. Akademie der Wissenschaften* erscheinen."

In connection with this report the President mentioned also Dr E. Rabe's adaptation of the Berkeley Tables of the Hecuba group to machine computation, *Berlin. Sitz.-Ber.* **18**, 1937, and his successful application of the Tables to 62 Erato, *A.N.* **262**, 1; and 90 Antiope, *A.N.* **264**, 18.

Frankfurter Planeten-Institut. No further report having been received the President mentioned that in accordance with the procedure recommended by him Dr Boda had redetermined the perturbations of 46 Hestia. Dr Boda's account of the work communicated by letter in 1935 is as follows:

"Ich ging dabei von einem oskulierenden Elementensystem aus, indem ich die Störungen in Exzentrizität und Perihellänge genähert berechnete und so für diese Elemente genäherte 'mittlere' Elemente erhielt. Die Länge zur Nullepoche und die mittlere Bewegung wurden aus weit auseinanderliegenden Beobachtungen ermittelt. Die so erhaltenen Werte stellten die dazwischenliegenden Beobachtungen mit befriedigender Genauigkeit da, ohne dass irgend eine Ausgleichung notwendig gewesen wäre. Wir sind also in der Lage auf Grund des von Ihnen angeregten Verfahrens für die Planeten für die oskulierende Elemente vorliegen, in einfacher Weise 'mittlere' Elemente abzuleiten unter Benutzung der Tafel im dritten Teil der Brendel'schen *Theorie der kleinen Planeten.* Da sich diese Tafeln über mittlere Bewegungen von etwa 700″ bis 1200″ erstrecken, hat man nun in Verbindung mit Ihren Tafeln bis auf eine kleine Lücke die Möglichkeit für alle Planeten über 540″ in entsprechender Weise vorzugehen. Allerdings scheint es mir nicht zweckmässig in solchen Fällen in denen oskulierende Elemente nicht vorliegen, diese erst abzuleiten. Vielmehr würde ich es vorziehen die mittleren Elemente unmittelbar aus den Beobachtungen abzuleiten. Die Kenntnis dieser Elemente ist einmal wichtig für die Zwecke des Recheninstituts, d.h. für die genäherte Ephemeridenrechnung, vor allem aber bilden sie die Grundlage für die genauere Störungsrechnung, die ja unser eigentliches Ziel ist."

Later Dr Boda wrote as follows:

"Ich habe mittlerweile mehrere Planeten der Hestia-Gruppe und zwar solche, deren mittlere Bewegung sehr nahe bei 900" liegt, unter Benutzung der oskulierenden Elemente verbessert und fast durchweg guten Erfolg erzielt. Die Notwendigkeit einer Ausgleichung aller Elemente ergab sich nur in solchen Fällen, in welchen die oskulierenden Elemente noch nicht genügend sicher waren. Ich hoffe, dass es uns gelingt, diese Methode noch häufig anzuwenden."

Astronomical Institute of Leningrad. No report having been received from the Leningrad Institute, the President mentioned several of its publications:

"Methods and Results of Planetary Work at the Astronomical Institute of Leningrad" (*Astronomical Journal of the Soviet Union*, **12**, 5, 1935), published in connection with the fifteenth anniversary of the Institute.

On the Determination of the General Perturbations of the Minor Planets of the Minerva Group (700"–800") (Moscow, 1935), also "Approximate Tables of Perturbations for Minor Planets of the Minerva Group" (*Journal des Observateurs*, **19**, no. 3, p. 33, 1936). These tables have been applied to ten minor planets: 22 Kalliope, 216 Kleopatra, 266 Aline, 308 Polyxo, 349 Dembowska, 371 Bohemia, 427 Galene, 503 Evelyn, 558 Carmen, 833 Monica.

"Application of the Method of Extrapolation to the precise Calculation of Perturbations of the Minor Planets" (*J.O.*, **18**, nos. 9–10, p. 153).

Bulletin of the Astronomical Institute, no. 43. This is the first of an annual publication of the elements, perturbations and ephemerides determined at the Leningrad Institute and by co-workers in other Russian observatories, etc. The elements and ephemerides are reproduced in the *Kleine Planeten*, 1938. No. 43 contains the osculating elements of 88 minor planets, the action of Jupiter and Saturn being included by the extrapolation method, and the mean elements of six minor planets, based on the tables for the Minerva group. Accurate ephemerides which include the perturbations by Jupiter and Saturn by the extrapolation method are given for 1 Ceres, 2 Pallas, 3 Juno, and approximate ephemerides for 79 planets.

Observatoire Astronomique Zô-Sè. The 1935 report by E. de la Villemarqué, S.J., unfortunately did not reach the President in time to be included in the *Trans. I.A.U.* for 1935, having been forwarded from Paris to the United States. Subsequently in September 1935 a supplementary report was received and a further report covering the past three years was sent to Stockholm. On the basis of these reports the President has prepared the following statement and summary of activities. The results achieved at the Zô-Sè Observatory constitute an outstanding contribution to our knowledge of the elements and perturbations of minor planets and serve admirably for the calculation of annual ephemerides. Observations, elements, and perturbations have been published in the *Annales de Zô-Sè*, the *A.N.*, the *J.O.* and *K.P.* The work includes observations, special perturbations, and general perturbations by the Brendel, Gyldén, and Bohlin methods. For the latter Strömberg's tables have been used for Jupiter perturbations and Block's tables for Saturn perturbations. They have been applied to 112 planets with mean motion from 975" to 1150". Terms of higher rank have been obtained by the method of Cauchy and terms of higher degree which do not figure in the tables by the method of Bohlin. This refers particularly to the terms 1–3, 1–4 and 2–7 for Strömberg's tables.

For 24 planets with mean motion between 1000" and 1100" elements have been determined from observations with consideration of perturbations. For these planets mean elements or constants of integration have been determined from the observations. For 8 other planets, the elements have been determined from the observations. One planet, 113 Amalthea, should be especially mentioned on account of the precision of the elements and perturbations. The method of Brendel was applied for the determination of perturbations of 50 planets for 1930–40. A table has been constructed for planets with mean motion between 1250″ and 1350″. With the Strömberg and Block tables perturbations have been computed for 112 planets. In case of accurate osculating elements and complete perturbations the constants of integration have been derived under the usual condition that the perturbations and the first derivatives shall be zero at the epoch of osculation, otherwise mean elements have been determined from observations. The constants of integration and change of elements have been checked by graphical methods. The programme aims at an average precision of $0^{m}\cdot1$ and 1′ for a period of 50 years in favourable cases. With few exceptions all computations have been based on the elements of *V.R.I.* no. 45. For convenience the expressions "constants of integration" and "corrections to the elements" have been used without discrimination. In particular, for planets 80, 207 and 228, the corrections of the elements are transformed into constants. Modifications of the theory of the planets for the present will not be in the elements but through corrections, additions, etc., of the perturbations. De la Villemarqué points out the difficulty of finding the true mean motion which he obtains from distant observations in the same part of the orbit. The following is a verbatim quotation from the 1938 report:

"Quand j'ai commencé mon travail pour déterminer les constantes d'intégration, je n'avais pas de bons éléments osculateurs, mais seulement *V.R.I.* No. 45. J'admets donc que les perturbations générales sans constantes seraient légèrement modifiées si on prenait d'autres éléments. J'ai indiqué (*Annales de Zô-Sè*, **19**, fasc. 2, p. ix, 1935, et **21**, fasc. 1, p. 45) les très petites corrections à faire de ce chef.

Pour déterminer les constantes, j'ai écrit qu'à l'osculation, perturbations et dérivées sont nulles. J'ai traité ainsi 80, 207, 228, 149, et 113. J'ai dernièrement traité de même 270, 317, 345, en utilisant votre inestimable *Research Surveys*, II (Lick, **19**, 1935). Puis j'ai contrôlé les résultats obtenus par un certain nombre d'observations. Pour 113, je donne les résultats (*Annales de Zô-Sè*, **17**, fasc. 5) en exposant la méthode. Pour 80, 207, 228, dans *J.O.* **13**, 172. Pour 149, 270, 317, 345, je n'ai rien publié. Le résidu est 1′. En résumé je n'ai déterminé les constantes que de 30 planètes: *80*, *113*, 136, *149*, *208*, *228*, 254, *270*, 281, 291, 298, *317*, 326, 336, 341, *345*, 364, 367, 370, 376, 391, 422, 434, 440, 443, 453, 540, 548, 641, 654. Les planètes imprimées en italique ont leurs constantes déterminées par la théorie. Les autres, par la méthode des moindres carrés. Mais, par la théorie seule, il est impossible de déterminer le moyen mouvement moyen. Force est donc de prendre une observation éloignée de l'osculation et de contrôler les constantes par deux autres observations. Les O–C de 113 sont donnés dans *Annales de Zô-Sè*, **17**, fasc. 5. Ceux de 434 dans *A.N.* **251**, 124. Les autres dans *J.O.* **13**, 172; **15**, 35; **17**, 14. Pour 149, 270, 317, 345 les O–C sont 1′."

The remainder of the 1938 report gives details concerning the treatment of the equations of condition in the plane and in space.

The following is an extract from a report of Director Delporte:

Observatoire Royal de Belgique (*Uccle*). Service photographique des petites planètes. Période juillet 1935–fin mai 1938.

"Instruments: Pendant cette période (1) l'astrographe double Zeiss de 400 mm. de diamètre et 2 m. de longueur focale a été consacré presque entièrement au programme d'observation des petites planètes. La méthode d'observation à doubles poses (barre-point) sans modification de centre a été la règle. L'observation d'astres

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très faibles a été fait par la méthode Trépied-Metcalf; (2) l'astrographe simple Zeiss (300 mm.–1500 mm.) a continué son activité dans le même domaine durant le second semestre 1935 et une partie de 1936. Fin 1936 et durant l'année 1937 et le début de 1938 cet instrument muni de son prisme objectif a servi à recherches en cours d'exécution actuellement qui ont trait aux astéroïdes (variation d'éclat, rotation). (3) Quelques plaques pour la recherche d'astéroïdes ont été prises en 1935 et 1936 à l'équatorial de la Carte du Ciel. (4) Egalement le service du télescope Zeiss (miroir 1 m., focale Cassegrain 10 m.) a posé quelques plaques pour mesures de positions d'astéroïdes. (5) Le service des petites planètes a fait l'acquisition d'une machine permettant la mesure des clichés jusque 30 × 30 cm. Cette machine est entrée à l'Observatoire au début de 1938.—Conditions climatériques: L'Observatoire d'Uccle s'est trouvé depuis novembre 1936 jusqu'à maintenant (juin 1938) dans des conditions de ciel très défavorables. Les résultats, malgré une activité soutenue sont donc moins brillants que durant la période 1932–35.—Le personnel disponible pour le service des astrographes a été également plus réduit que pour la période triennale précédente, notamment par suite du voyage en Amérique de M. Arend de septembre 1935 à juillet 1936 et de l'affectation de cet astronome après son retour, principalement à l'équatorial visuel de 45 cm.—Relevé statistique, 1935 juillet à 1938 juin: nombre de plaques, 813; planètes nouvelles découvertes, 88; planètes anciennes observées, 684; positions approchées: planètes connues, 990, planètes nouvelles, 53; positions précises: planètes connues, 406, planètes nouvelles, 400; nombre total de positions, 1849. Depuis le précédent rapport (juillet 1935) 16 planètes ont été numérotées au profit de l'Observatoire d'Uccle: E. Delporte 1335, 1341, 1350, 1361, 1363, 1366, 1374, 1375, 1386, 1388, 1401, 1433; S. Arend 1348, 1352; F. Rigaux 1378; J. Hunaerts 1423. La planète spéciale 1936 CA a reçu le nom de 'Adonis'.—Calculs d'orbite de planètes trouvées à Uccle (*Bulletin Astronomique de l'Observatoire royal de Belgique*, 1936–8): 1363, 1936 QK, 1378, 1936 FI, 1936 QM, QN, QO, 1433.—Réductions spéciales: le calcul définitif des positions de l'astéroïde 433 Eros résultant des positions obtenues pendant l'opposition 1930–31 à l'astrographe triplet Zeiss (300 mm.–1·50 m.) a été publié avec tout le détail demandé, y compris l'amélioration résultant des positions définitives des étoiles de 1er ordre. (1) Observations de l'astéroïde 433 Eros par E. Delporte et S. Arend (*B.A.B.* **2**, no. 7, 1936, pp. 157–65). (2) Amélioration des observations de l'astéroïde 433 Eros effectuées pendant l'opposition de 1930–31 par E. Delporte et S. Arend (*B.A.B.* **2**, no. 10, 1938, pp. 217–18). Les positions du même astéroïde obtenues à l'équatorial photographique de la Carte du Ciel par M. Delvosal et J. Warzée ont été expédiées en manuscrit à M. l'Astronome royal d'Angleterre à Greenwich. Elles paraîtront dans le prochain bulletin de l'Observatoire d'Uccle, *B.A.B.* **2**.—Travaux spéciaux relatifs aux astéroïdes: (1) La découverte et le dépouillement des plaques de la planète 1936 CA = Adonis, a donné lieu aux travaux suivants: P. Bourgeois et J. Cox, "Sur les conditions d'observation de la petite planète Adonis" (*Bull. de l'Académie royale de Belgique, Cl. des Sciences*, **22**, 855–63); S. Arend et J. Hunaerts, "La magnitude absolue de l'astéroïde Delporte 1936 CA = Adonis" (*B.A.B.* **2**, no. 5, 1936, p. 113). (2) Technique de réduction: S. Arend, "Note sur le réglage de précision du porte-chassis d'une chambre photographique astronomique" (*Comptes-rendus du 2 Congrès national des Sciences*, Bruxelles 1935, **1**, 250–54); S. Arend, "La précision des positions d'astéroïdes à l'astrographe simple de Zeiss" (*B.A.B.* **2**, no. 6, 1936, pp. 129–37); S. Arend, "Note concernant le rattachement d'un astre à quatre étoiles de repère" (*B.A.B.* **2**, no. 9, 1937, pp. 199–200); S. Arend, "Sur le rattachement d'un astre à un nombre quelconque d'étoiles de repère, par les méthodes des masses coordonnées" (*Bull. de la Société belge de photogrammétrie*, 1936, no. 8, pp. 5–14); S. Arend, "Calcul direct des dépendances utilisées en astrographie de position" (*Bull. de l'Académie royale de Belgique, Cl. des Sciences*, 1937, no. 5, pp. 476–82); S. Arend, "Réduction de la position astrographique d'un astre en se servant des coordonnées sphériques" (*J.O.* 1937, **20**, no. 11, pp. 185–8).

Mr T. Banachiewicz reported the following brief summary of recent work by himself and collaborators:

"An interpretation of the Gaussian triangle quotients n_1 and n_3, simplifying and completing the theory of orbit determination. Formulae for the rectangular co-ordinates, which can be used without the knowledge of the elements ☊, i, ω, or other equivalent elements, and the arithmometric formulae giving ☊, i, ω, without the previous determination of the Gibbsian constants. Simplification of the Gaussian method of orbit determination by the variation of the geocentric distances. Generalization of the formulae of Kühnert and Merton for the rectangular co-ordinates and velocity projections, etc. *Acta Astronomica*, A, **3**, 53–6.—The cracovian formulae for the determination of the astrographic positions from two or more comparison stars. *Cracow Observatory Reprint*, 9.—Numerical examples for the cracovian formulae of the determination and the correction of orbits (L. Stankiewicz). Reprint 12.—On the exactitude of the different formulae for the triangle quotients n_1 and n_3 (K. Koziel). Reprint 13, 16.—The general principles of the determination of the exactitude of an orbit based upon three observations, with S. Kaczmarz, K. Koziel, S. Piotrowski, L. Stankiewicz. Further development of these principles, as yet unpublished, was made in 1938 by K. Steins. Reprint 15.—General formulae for the solution of the linear equations by the methods of the cracovians. Reprint 18.—Analysis of the number of the arithmetic operations needed in the calculation of the inverses (i.e. in the indeterminate solution of the linear equations) by the cracovian method (L. Stankiewicz). Reprint 17.—Formulae for the calculation of the determinants and the inverses. It is shown that the determinants can be effectively used without disadvantage for the solution of the linear equations. Remark on the role of the indeterminate solution in definitive orbit calculations. *Acta Astronomica*, C, **3**, 41–67.—Application of the cracovians to the different elementary analytical problems (A. Chrominski). Reprint 19.—The number of the arithmetic operations in the computation of the determinants and in the numerical solution of the linear equations by the method of cracovians. Reprint 20.—Principles of a cracovian method of the solution of the normal equations of the method of the least squares, affording a great saving of labour, which has been needed in the application of the classical astronomical methods. *Bull. Acad. Pol.* 1938, 134–5.—Fundamental equations (of two types) between the elements of a little-circles spherical polygon. *C.R. Acad. Pol.* May 1938.—Solution of a problem, which has been left open by Gauss, on the influence of the weights of the equations of condition upon the results of the computations according to the method of least squares. *Acta Astronomica*, C, **3**, 111–17.—On rotations in 4-dimensional space and two aspects of the fundamental equations of spherical polygonometry. *Bull. Acad. Pol.* 1938. From the point of view of spherical astronomy this work shows how the generalized equations of Gauss on the one hand and those of Delambre on the other, relative to spherical polygons, may be viewed as two different aspects of the same fundamental relation."

Prof. M. Kamieński's report on his investigations on the motion of Comet Wolf I:

"During the years 1935–8, further computations on the motion of this comet were made at Warsaw.

1. With the collaboration of M. Bielicki, an exhaustive definitive study was made of the motion of the comet in 1925. The system P_{15} of its elements represents all the observations with the maximum deviations:

$$\Delta\alpha \cos\delta = -5^s\cdot16 \quad \Delta\delta = +4''\cdot8 \quad \text{Sept. 1925.}$$

It was not possible to get better results with the above system, which, however, represents fairly well all the observations during 1884–1919.

2. The perturbations due to Uranus were computed and revised for the whole period of visibility of the comet, i.e. for 1884–1934.

3. The perturbations due to Venus, Earth, Mars, Jupiter and Saturn were computed very carefully and revised for the next period 1925–34.

4. For the apparition of the comet in 1933–4 a definitive comparison between the observations and the theory was made. It was found that all the observations in 1933–4 were represented quite well with the system P_{16}:

1933	$\Delta\alpha \cos\delta = +0^s\cdot55$	$\Delta\delta = +5''\cdot7$	before perihelion passage
1934	$\Delta\alpha \cos\delta = -0\cdot49$	$\Delta\delta = -4\cdot0$	after perihelion passage.

We can admit that these deviations are zero for the time of perihelion passage 1934 Feb. 27·95 U.T. It must be noted that this system P_{16} of the elements represents all the observations of the comet for the period 1884–1934 quite well, except for the small irregularity for 1925, on the condition: $n = n_0 - 0''\cdot000\,000\,42\,(t - 1884$ Sept. $24\cdot0)$. The results of these investigations were published in the *Reprints of the Warsaw Observatory*, nos. 32, 33, 34.

5. Further, the perturbations due to Mercury and Neptune were carried out for the whole period 1884–1934. It seems, however, that the results of the comparisons between the normal places and the theory do not change considerably, when taking the influence of these two planets into consideration.

6. The new theories of S. Vsekhsvyatsky concerning diminution of brightness of short-period comets as well as his conclusions about their age (the maximum age of Comet Wolf I is 120 years; probably, however, it is much younger) in connection with the known views that such comets may be eruptions from Jupiter, induced Prof. Kamieński to investigate the past motion of this comet. According to this plan, the perturbations backward from 1884 must be computed until the distance between the comet and Jupiter's surface becomes zero. This task is aggravated by the very close approach of the comet to Jupiter in 1875 when Δ min. = 0·12, according to Lehmann-Filhés' investigations in *A.N.* 2953. Computation of the perturbations due to Jupiter and Saturn from 1884 back to the moment of entrance of the comet into the sphere of activity of Jupiter in 1875 is completed."

Astronomical Observatory, Azabu, Tokyo. Report of Prof. K. Hirayama, supplemented by Prof. Y. Hagihara:

"Since 1933, S. Kanda, H. Hirose and three volunteer computers I. Imai, Y. Simidu and K. Takahasi have calculated circular orbits of 320 asteroids, of which 140 could be identified with objects already known. The asteroids newly numbered according to these identifications are as follows: 1265, 1266, 1267, 1272, 1283, 1302, 1303, 1304, 1307, 1309, 1311, 1330, 1331.

Hirose has determined 21 elliptic orbits. The elements and the yearly opposition ephemerides of the following 22 asteroids are in his care: 870, 913, 963, 1129, 1148, 1223, 1245, 1266, 1283, 1302, 1303, 1304, 1307, 1309, 1311, 1331, 1345, 1346, 1347, 1350, 1365, 1383.

K. Hirayama and K. Akiyama have computed the special perturbations of the asteroid 153 Hilda by Jupiter and Saturn from 1785 to 1956, and improved the elements on the basis of 31 oppositions. They have ascertained by this means the librating character of the asteroid which is in agreement with the conclusions of Laves and Brown. They find that the variation of the argument $\theta = 2L - 3L' + \bar{\omega}$ is approximately represented by a sine curve the equation of which is

$$\theta = 40^\circ\cdot 02 \sin \{67^\circ\cdot 4 + 0^\circ\cdot 869\ (t - 1900\cdot 0)\}$$

(*Japanese Journal of Astronomy and Geophysics*, **15**, 142). (In presenting this report the President expressed the opinion that the special perturbations had not been carried over a sufficient period of time to make the results conclusive.)

Hirayama and Akiyama are supplying the Rechen-Institut with the elements and the opposition ephemerides of the following 37 asteroids: 7, 153, 195, 290, 441, 548, 677, 701, 774, 801, 814, 815, 819, 825, 845, 850, 852, 854, 857, 860, 901, 914, 917, 920, 923, 924, 932, 945, 951, 966, 985, 1088, 1089, 1090, 1098, 1139, 1185.

Oikama of the Tokyo Astronomical Observatory is now working on the photometry of some of the asteroids by photographic methods with a Brashear 12″ refractor. The result will soon be published.

Several observations of the variability of Eros were made by Kanda and his collaborators and have been published in Japanese.

The plates for Eros taken with the 26″ refractor according to Dr Spencer Jones' programme are now being measured. The measurements will be finished toward the end of 1939.

The computation of ephemerides for several asteroids by the method of special perturbations is being continued by Akiyama under the guidance of K. Hirayama."

Prof. Dirk Brouwer sent the following statement by Dr W. J. Eckert on the Astronomical Hollerith-Computing Bureau and a report on the asteroid work by Brouwer and Eckert:

"The Astronomical Hollerith-Computing Bureau is a scientific, non-profit-making organization whose purpose is to make the punched-card method of computation available to astronomers. It is a joint enterprise of the International Business Machines Corporation, Columbia University, and the American Astronomical Society.

The computation of special perturbations and the numerical integration of the equations of planetary motion are performed automatically on the machines of the Bureau. A description of the method is given in *A.J.* 1034. Since then an automatic switching device has been installed and the details of the card manipulation have been improved.

The plan of organization of the Bureau is given in *Publications of the Astronomical Society of the Pacific*, **49**, no. 291.

Programme for the determination of systematic corrections to star positions from observations of minor planets. Photographic observation of the fourteen asteroids listed in *A.J.* 1022 and two additional ones, 27 Euterpe and 433 Eros, has been in progress since 1935, the Allegheny Observatory co-operating with the Yale Observatory. By the end of April 1070 asteroid plates had been obtained with the long-focus telescopes at Johannesburg and at Pittsburg, and 820 short-focus plates with the Ross Cameras at Johannesburg and at New Haven. The majority of the latter do not show an asteroid image; their main purpose is to provide positions of the comparison stars on the long-focus plates.

The plates are being measured at New Haven, where a systematic measuring programme began last winter. About 200 plates have so far been measured. The

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available number of positions will soon be sufficient to afford a test of the accuracy.

The orbits of these planets are being improved by numerical integration and comparison with observations beginning with 1930 or earlier. Over half of the first integration has been completed. This is a joint enterprise of Eckert (Columbia) and Brouwer (Yale), with the assistance of various members of the two observatories. Three orbits have been published in preliminary form: 287 Nephthys in *A.J.* 1069, 532 Herculina by F. H. Hollander in *A.J.* 1070, and 6 Hebe by H. G. Hertz in *A.J.* 1082.

A method of differential correction of orbits with the use of rectangular co-ordinates, the initial development of which is due to Eckert, has been published in *A.J.* 1069 by Eckert and Brouwer. The problem of the accumulation of errors in numerical integration was discussed by Brouwer, *A.J.* 1072."

Report of the *Berkeley Astronomical Department*:

"In addition to the continuation of the Research Surveys the President mentioned that the application of the Berkeley Tables to critical cases of the Hecuba Group is being continued by Ellen Jane Barndollar under the immediate supervision of Dr Sophia H. Levy. So far the general perturbations of 21 minor planets have been developed at Berkeley. Only in rare cases has it been found necessary to improve all the elements by least squares reductions. In this connection he called attention to the following two publications: *The Story of Andromache, An Unruly Planet*, by A. O. Leuschner (*Publications of the A.S.P.* **48**, no. 282) and *The Effect on Prediction for Minor Planets of the Hecuba Group produced by Terms not included in the Berkeley Tables of Perturbations*, by A. O. Leuschner, Sophia H. Levy, Claude M. Anderson Jr., Ellen Jane Barndollar (*Publications of the A.S.P.* **49**, no. 290).

The President also mentioned his Halley Lecture delivered at Oxford on June 16, 1938, entitled "The Hecuba Group of the Minor Planets", and stated that arrangements were under way for the printing of the lecture. In addition to Miss Levy and Miss Barndollar, W.P.A. workers under the direction of supervisor Dr Katherine Kaster have assisted in the preparation of material for the lecture.

The President also mentioned "Tafeln zur Berechnung genäherter allgemeiner Jupiterstörungen für die Kleinen Planeten des 2/5-Typus" by J. G. Behrens and "Genäherte Jupiterstörungen für 47 Kleine Planeten" by G. Raynal and J. G. Behrens (*A.N.* **255**, nos. 6110–11). The latter is an application of the preceding tables to 47 planets for which the angle of eccentricity is greater than 10°. The starting elements are those published in *K.P.* for 1933.

The President also mentioned "Vereinfachte Formeln der Differentialquotienten bei genäherter elliptischer Bahnverbesserung nach Brendel" (*A.N.* **260**, 273) and "Die Struktur der Hestia-Lücke im System der Kleinen Planeten" (*A.N.* **260**, 177) by K. Schütte.

The President also mentioned "Untersuchungen zur Hecubabewegung und analoger Bewegungsformen" by A. Wilkens (*Abhandlungen der Bayr. Akad. d. Wissenschaften, Math.-naturwiss. Abteilung*, N.F., Heft 27, 1935).