

starting point and stimulus for much of this latter work. A comprehensive and independent observational check of the FK<sub>4</sub> system is being provided by the gradual realization of the programme envisaged by Professor Danjon soon after he introduced the prismatic astrolabe to astronomy.

#### CATALOGUES

The past three years have seen the completion by the Babelsberg Observatory of both the *Geschichte des Fixsternhimmels, Abteilung II (Southern Sky)* (1) and the *Index der Sternörter 1925-60, Index II* (2). They have also seen the first publication of an extremely useful comprehensive star catalogue by the Astrophysical Observatory of the Smithsonian Institution (3). This catalogue gives the positions and proper motions on the FK<sub>4</sub> system of 258 997 stars between declinations +80° and -80° for the epoch and equinox of 1950.0. It is based on a combination of the FK<sub>4</sub>, FK<sub>3</sub>, GC, AGK<sub>2</sub>, AGK<sub>1</sub>, Greenwich AC, Yale, CPC<sub>50</sub>, CAZ, Me<sub>3</sub> and Me<sub>4</sub> catalogues. Unfortunately it did not also incorporate the section of the CPC<sub>50</sub> between -64° and -80° (69) which would have greatly strengthened what is, at present, its weakest part. Much of the work of preparation of the SAOSC was done on an electronic computer as it was intended to provide the fullest possible list of reliable star places in computer-accessible form to speed up the derivation of accurate positions of artificial satellites from the thousands of photographs being taken by the Smithsonian Baker-Nunn cameras all over the world. The catalogue is available on magnetic tape compatible with IBM 729 tape units and also in book form.

At the Astronomisches Rechen-Institut, Heidelberg, work on problems relating to the preparation of fundamental catalogues has gone on steadily. A report on the formation of the declination system of FK<sub>4</sub> and on the derivation of individual corrections to positions and proper motions from differential observations was given by Kopff, Nowacki and Strobel (42). The same authors, together with Mürle (41), published formulae and tables for the reduction of small proper motions and co-ordinate differences which had been used in the construction of FK<sub>4</sub>. While the systematic differences FK<sub>4</sub>-FK<sub>3</sub> were given in FK<sub>4</sub>, tabulated differences FK<sub>4</sub>-GC and FK<sub>4</sub>-N<sub>30</sub> were published by Brosche, Nowacki and Strobel (12). In continuation of previous lists of star catalogues Heinemann (32) compiled a list of catalogues from 1900 to 1962.

An investigation of the stability of systems of positions was carried out by Gliese (30) in making use of the  $\alpha_\delta$ -systems of fundamental observations with transit instruments from 1840 to 1958.

The apparent places of the stars included in FK<sub>4</sub> Supp are not being given in the annual international volumes 'Apparent Places of Fundamental Stars'. They have, however, been computed for all 1987 FK<sub>4</sub> Supp stars at Heidelberg from 1965 onwards. They are available to observers on request.

A method for deriving systematic differences in star positions between different catalogues was developed by Brosche (13). The differences are expanded in spherical harmonics, and the highest order of the expansion is determined by applying the  $\chi^2$ - or F-test. The method, slightly modified, will be used in the machine computation of the systematic differences between FK<sub>4</sub> and important observational catalogues. The work is part of a current project to revise the Albany General Catalogue and to prepare future improvements of FK<sub>4</sub>. For the same purpose the Astronomisches Rechen-Institut, in co-operation with the U.S. Naval, the Yale and Potsdam-Babelsberg Observatories, has continued to place a large number of star catalogues on punch cards. Lists of other star catalogues and astronomical data available in machine readable form are given in U.S. Naval Observatory Circulars Nos. 99 and 111.

Fricke (27, 29) has carried out comparisons of the distance scales which can be established from secular parallaxes on the basis of the proper motion systems of GC, N<sub>30</sub>, FK<sub>3</sub> and FK<sub>4</sub>.

Work on the determination of the correction to lunisolar precession and of the galactic constants A and B on the basis of the various proper motion systems is in progress. For further details see report of Commission 33.

At Uccle, Professor Melchior has prepared a catalogue of all the meridian observations of latitude stars and has deduced the best positions and proper motions for 1950.0 on the FK4 system. The calculations were carried out on an IBM 1620 and can easily be revised when new observations of the stars become available. A catalogue of the positions of 939 PZT stars as observed with the Washington seven-inch transit circle has been completed by J. A. Hughes. It appears in University Microfilms, Chicago, Illinois, 1966 and a discussion of it will be given in the Publications of the U.S. Naval Observatory.

A catalogue of the positions of 240 stars in the Mizusawa, Richmond, Tokyo and Washington PZT lists has been published in Tokyo by H. Yasuda and H. Hara (88). The Mizusawa PZT star positions have been revised by utilizing the results of observations made during the period from 1958 to 1961. The revised declination system seems to be closer to the GC than to FK3, while the revised right ascension system is consistent with that of Washington.

By analysing the meridian observations of the four brightest asteroids made at the Cape, Tokyo and Washington during the period 1950–62, H. Yasuda has shown that it is possible to derive not only improved equinox and equator points but also improved elements of the Earth's orbit (87). At Washington the results of a discussion of the observations of these four brightest asteroids made between 1920 and 1960 are being prepared for publication in the *Astronomical Journal*.

Professor Melchior has made a theoretical investigation of the close relationship between the phenomenon of precession and nutation and the terrestrial tides (51). He found that corrections to the amplitudes of the short period nutations are necessary and that these can be obtained from observations made with horizontal pendulums.

#### OBSERVATORIES — PROGRAMMES AND INSTRUMENTS

The observations for the AGK3R with the Babelsberg meridian circle came to an end with the death of Professor Wünschmann. It has been decided not to complete the reductions of the observations already made partly because they can not be ready in time for inclusion in the final catalogue and partly because they seem to be affected by an instrumental fault that was not detected until after many of the observations had been made. The meridian circle has now been thoroughly examined and after overhauling is to be transferred to the Potsdam Geodetic Institute where its first work will be the observation of reference stars for the PZT. This latter instrument (250/3780 mm) was built in the workshops of the Babelsberg Observatory but after testing is being transferred with the transit circle. Professor Dick has considered some of the problems of a horizontal transit circle (18).

At Belgrade the Askania meridian circle (190/2578 mm) is being used for differential observations to obtain the declinations of 3245 stars which form the latitude programmes of 19 observatories. The Askania transit circle (190/2578 mm) is being investigated in preparation for the determination of absolute right ascensions while absolute declinations will be found with the Askania vertical circle (190/2578 mm) as soon as some technical difficulties with the instrument have been sorted out. The systematic determination of the declinations of 36 zenith stars according to the programme of Ševarlić and Teleki (66) is being continued with the Askania zenith telescope (110/1285 mm). This programme was begun in 1960 and is expected to run to 1980.

Observations for the third Besançon meridian catalogue were completed in January 1964 and the catalogue itself published in 1965 (50). It contains 1090 stars of which 326 are included in the FK3, 429 of the others in the GC and 806 in Blaauw's list. A second publication, now in preparation, will give the proper motions of 764 of the stars.

At Bordeaux, M. Requième has built a micrometer incorporating a Lallemand photo-multiplier cell that automatically registers the times of star transits across the meridian. With it one can observe stars down to magnitude 8.9 with equal accuracy for all declinations between  $-20^\circ$  and  $+75^\circ$ . M. Requième's work is described in a thesis which is to be submitted in October 1966.

The Brorfelde transit circle has been equipped with a new photographic micrometer, by means of which about 10 000 observations have been made since 1964. High accuracy in the tracking of stars during transit has been obtained through an electronic velocity-generating device which makes the plateholder-carriage to move uniformly and with a rate matched to that of any star within 0.1%. A new and accurate method of photoelectric recording of the circle in machine-readable form has been in use since December 1965. Recently all 2160 diameter corrections were determined by this method with an accuracy of 0".03 (m.e.); the diameter correction measurements were carried out in about 15 hours and the complete reduction in 20 hours, and it is therefore intended to repeat the determination with short intervals in order to investigate the stability of the glass circle. Night-to-night comparisons of differential observations give the internal mean errors  $\epsilon_\alpha \times \cos \delta = 0".013$  and  $\epsilon_\delta = 0".20$  for a single observation of a star brighter than the visual magnitude 8.5 and somewhat larger errors for fainter stars.

The Cooke transit circle at Herstmonceux is engaged on a programme of stars selected from the General Catalogue of Radial Velocities as having well determined radial velocities but poor proper motions. The graduation errors of the 'primary divisions' ( $0^\circ$ ,  $20^\circ$ ,  $40^\circ$  etc.) of the circle have been determined photographically and the results found to be in good agreement with the values adopted from the visual measurements made in 1936-40. A new determination of the pivot errors made with an auto-collimator agrees very well with that made in 1948. A definitive investigation of the instrumental system during the years 1957-61 based on an analysis of over 21 700 observations of FK4 stars made during the AGK3R programme is in progress.

Revised proper motions on the FK4 system have been determined for 182 semi-regular and RV Tauri-type variable stars. Of these, 44 were selected as being in particular need of modern positions. These were obtained differentially from observations made with the Cooke transit circle of each variable and six adjacent FK4 stars. The results will be published in a forthcoming Royal Observatory Bulletin.

Meridian observations at La Plata have been temporarily interrupted because the transit circle has been transferred to the Southern Astrometric Station at La Leona where it has been used since 1965 for the observations of the absolute declinations of southern FK4 stars and also of 'Kustner Series'. The transit circle lent by the Lick Observatory is being reconditioned prior to installation at La Plata. The reduction of observations made in former years has continued and the systematic differences between the 'instrumental' and 'fundamental' declination systems have been evaluated for the FKSZ stars.

The Munich vertical circle continues to be used for the observations of the absolute declinations of FK4 stars, the major planets and the four brightest asteroids.

The Ottawa mirror transit was brought into operation in February 1965. Results indicate a probable error in right ascension of slightly less than 0".25; the probable error in declination was not known at the time of reporting as the automatic engine for measuring the circle films was being modified. A new PZT is to be established a few miles due west of the present instrument. When the new PZT is in operation, the old one will be moved to a site near Calgary, Alberta where it will be on the same latitude as Herstmonceux.

Trials on the mirror transit circle of the University of Porto Observatory continue. A study of the flexure of the original axis indicated that it was dependent on the reaction of the pivots.

A new axis is therefore being built in the hope of eliminating this flexure. A grant from NATO has provided apparatus for the digital read out of the micrometers.

At Strasbourg, the observations of the double stars on Zverev's list and of the bright stars between  $+30^\circ$  and  $+72^\circ$  declination are nearly finished and it is hoped that the reductions will be completed within a year. P. Lacroute and P. Bacchus (44, 45, 8, 46) have shown that it is possible to improve the results of differential meridian observations significantly by reducing all the series of observations together and using a method they call 'synthèse'. This method has been applied to the Strasbourg AGK3R observations and the resulting gain in the weight is being investigated. P. Bacchus (7) has considered the problem of determining the systematic differences between catalogues by a statistical method. P. Lacroute (47, 48) has continued his studies of the use of overlapping plates in the formation of a photographic catalogue and has applied his method to plates of the AGK2 and AGK3.

Mr Harley Wood reports from Sydney that the Grubb-Parsons two co-ordinate measuring machine has now been received and will be used in the production of catalogues especially in the Sydney astrographic zone ( $-51^\circ$  to  $-65^\circ$ ). The measuring agent in each co-ordinate is a moire scale with digital read out so that all measures can be recorded on punched cards.

The positions of the Moon, exterior planets and the four brightest asteroids as observed at Tokyo during 1960 and 1962 have been published (85, 86). Observations of the Moon, inner planets, outer planets and the four brightest minor planets referred to the FK4 system are being continued with the Gautier meridian circle, as also are the observations for the SRS project begun in March 1963. This programme includes not only the SRS and 'Bright' stars between  $-10^\circ$  and  $-30^\circ$  but also fundamental stars between  $0^\circ$  and  $-35^\circ$ , near the zenith and in the northern sky. The readings of the circle films with the automatic photoelectric measuring machine are now registered in computer-readable form.

The Askania meridian circle at Uccle has been returned to the makers for various modifications including digitization. These modifications are now complete and the instrument is being remounted.

At Washington the programme of fundamental observations of the Sun, Moon, planets, four brightest asteroids, FK4 and FK4 Supp stars and 'Bright' stars north of  $-30^\circ$  declination, started with the six-inch transit circle in 1963, has continued. In conjunction with this programme, two observations are planned for the SRS stars north of  $-20^\circ$ . Provisional positions of the Sun, Moon, planets and asteroids are being published in the U.S. Naval Observatory Circulars a few months after the completion of the observations. The results of observations made with the six-inch transit circle between 1949 and 1956 have been published (5). A catalogue of the positions of the Sun, Moon, planets and the four brightest asteroids, FK4 and FK4 Supp stars as observed with the six-inch transit circle between 1956 and 1962 is nearly completed. The six-inch transit circle observations of the Moon made between 1925 and 1966 have been corrected for limb irregularities using Watt's charts and reduced to the FK4 system. B. L. Klock and D. K. Scott (39) have analysed the six-inch transit circle observations of the Moon made between 1952 and 1964 for a correction to the coefficient of periodic term 182 of Brown's Tables of the Moon. The correction found was in good agreement with the discordance found by Eckert and Smith (19) in their solution of the main problem of lunar theory.

The Washington seven-inch transit circle was taken out of service on 29 June 1965 to equip it for a programme of observations of fundamental and SRS stars at El Leoncito, Argentina, the site of the Yale-Columbia Southern Observatory. An excellent clock system and an improved photographic device for recording the readings of the micrometers have been acquired and the electrical connections pre-wired for rapid installation. It is expected that the instrument and associated equipment will be shipped from Washington during November 1966. A catalogue

of the Parenago stars and close double stars as observed with the seven-inch transit circle is being compiled by E. S. Jackson.

The pivot errors of the six-inch transit circle have been measured with a digitized auto-collimator designed automatically to monitor reflections from a mirror attached to one end of the axis. A full set of measures in one co-ordinate taken at  $10^\circ$  intervals can be obtained in less than ten minutes. A sidereal clock system planned by A. N. Adams and B. L. Klock has been installed for timing star transits. It has been possible to hold the epoch of the clock to within  $\pm 0.5$  millisecond for periods of several months.

A programme for the development of a new transit circle is in progress under the supervision of Adams and Klock. An electronic circle and automatic star and planet tracker are now being constructed at the Farrand Optical Company, Inc. A modified Cassegrain configuration is being considered for the instrument itself and special attention is being given to reducing the flexural and thermal errors known to exist in present transit circles.

#### ASTROLABES

Several Danjon Prismatic Astrolabes are now in use throughout the world. Since their principal task is the precise determination of latitude and time, their work is normally reported to Commissions 19 and 31. A by-product of these routine observations is, however, of great interest to Commission 8 since an analysis of them over an extended period can yield relative star positions within a band of declination  $60^\circ$  wide. These positions have high individual accuracy and their zonal errors appear to be small. They are, therefore, eminently suitable for checking the systematic accuracy of star positions obtained from transit circle observations.

The first catalogue of astrolabe star positions was compiled at the Paris Observatory in 1961 and clearly demonstrated how valuable as a check such catalogues would be, especially if they could be compiled from a series of astrolabes well spread in latitude. Several observatories are now actively engaged on this work and have greatly extended their star lists so as to include as many stars suitable for making comparisons with the standard catalogues as possible.

From Paris, B. Guinot reports that independent catalogues are being compiled from observations made with the astrolabes at Paris, Haute-Provence and Besançon. Catalogues are also being compiled from the astrolabe observations made during the IGY at Tananarive and at Alger. They will also be compiled from astrolabe observations still being made (in co-operation with the Paris Observatory) at Alger, Quito and Santiago (Chile).

A collection of all such material is being made at Paris. At present it includes results from Paris, Neuchâtel, Curaçao, Tananarive and Potsdam. It is still too early to try to combine these data but a preliminary study of them has shown good agreement between them both as regards individual and systematic errors. It appears that the standard deviation of the angular errors (combination of errors in both right ascension and declination) in FK4 for 1962 was fairly homogeneous and about  $0.10$  between declinations  $+80^\circ$  and  $-25^\circ$ . South of  $-25^\circ$  it increases rapidly and becomes about  $0.25$  at declination  $-60^\circ$ .

An analysis of the results of the astrolabe observations made at Herstmonceux during 1959–63 is being prepared for publication. The catalogue contains 230 right ascensions and 141 declinations for a mean epoch of approximately 1962.5. Comparisons with other catalogues show that the systematic accuracy of the Herstmonceux results is comparable with those obtained from the Paris astrolabe and the Pulkova photoelectric transit instrument. The probable errors of the individual stars, including an allowance for systematic errors, compare favourably with the probable errors of FK4 for the epoch of observation.

Individual and systematic corrections to FK4 star places derived from observations made with the astrolabe at Potsdam have been published (34, 38). The removal of this instrument

from Potsdam, where it has been working in the time and latitude service since 1957, to an equatorial site is under consideration.

Also under consideration is the possibility of moving the Besançon astrolabe to a station at Rio Grande in the Argentine in latitude  $53^{\circ} 48'$  south and longitude  $67^{\circ} 47'$  west. This astrolabe has been used intensively for the past three years at Besançon.

At Quito, Dr Scheepmaker has continued without interruption the series of astrolabe observations he began in October 1963. His apparatus has been improved however by the installation on 1 May 1964 of new time equipment provided by the American Science Foundation of the United States and on 1 September 1964 a new Belin chronograph registering to 1/1000 second. Three of the 11 fundamental groups, each consisting of 28 FK4 stars, are observed per night as well as special 'catalogue groups' of FK4 and FK4 Supp stars. The observations are reduced in Paris on an IBM 7040 but the interpretation is done in Quito. The results of an analysis of the observations made between October 1963 and April 1967 will be published in *Boletin Astronomico del Observatorio Astronomico de Quito*, No. 1. This publication will give the individual corrections  $\Delta\alpha$  of 187 FK4 and 40 FK4 Supp stars,  $\Delta\delta$  of 113 FK4 and 6 FK4 Supp stars and systematic corrections to FK4, all between declinations  $-30^{\circ}$  and  $+30^{\circ}$ . It is hoped that the number of stars for which individual corrections can be found will rise to 600 within the next four years.

A Danjon astrolabe was installed at the International Latitude Observatory of Mizusawa in 1964 and the observing programme, begun early in 1966, is made up of FK4 and FK4 Supp stars, 131 of which are in common with Alger.

Mr R. D. Adams reports from New Zealand that observations with the Danjon astrolabe have been made regularly since 1964. Preliminary reductions for the 1964 observations have been carried out on an IBM 650 computer using a programme devised by B. Guinot. Reductions of the 1965 and 1966 observations will be made when the appropriate programme for the new Elliott 503 computer has been written. Mr Adams remarks:

'Our original plan of work with the astrolabe was to complete observations of basic star groups, then to assist in the compilation of a catalogue of southern stars, and eventually to pursue a study of stellar proper motion, but unless we can obtain the services of a qualified astronomer, it may be necessary to curtail this programme and even stop observations. In view of the contribution we can make to positional astronomy, the equipment we have available, and the large amount of work already done, I would be very sorry to see this done. If you know of any suitable astronomer who might be interested in undertaking this work for us, either on a permanent basis or for a period of a year or two, I would be very grateful if you could put us in touch with him.'

The astrolabe from Herstmonceux was transferred to the Cape in 1965 (71, 72, 73). The observing programme contains eight standard groups of 28 stars each and more than 1000 'catalogue' stars representing all suitable stars brighter than  $5^m.6$  in the FK4 and the 'Bright Star' list associated with the SRS project. The aim is for each star to be observed at least twice by each of five observers. Present indications are that the programme will be substantially completed by the end of 1968. The relatively small number of standard groups is to ensure the determination of reliable group corrections (74). Attempts to eliminate variation of prism angle by thermostatic control of the astrolabe building during the day have proved partially successful. The closing error in prism angle has been virtually eliminated, but individual nights still show significant prism angle variations. This is due to the difficulty of predicting night-time temperatures, and to variations of ambient temperature during the night.

The quality of the results obtained so far has been rather disappointing, due to the generally poor seeing. Allowing for the errors of the adopted star places, the average probable error of the observation of one star is about 20% larger than it was at Herstmonceux for the same

observers. A large seeing disk presents the astrolabe with what is essentially an extended object. The large effective  $f$ -ratio ( $f/90$ ) means that there is frequently insufficient contrast to enable faint stars to be observed. Observations are sometimes impossible even in clear conditions, either because of oscillation or blurring-out of the images.

This dependence of the quality of astrolabe results on the seeing has been utilized by French astronomers for testing possible observatory sites since the installation of an astrolabe on an expeditionary basis is a relatively cheap and simple operation.

Partly because of the scarcity of trained observers and partly to ensure the best possible conditions, several observatories have decided to co-operate in the establishment of a French National Station for Fundamental Astrometry. The quality of the seeing at three sites is being examined by a study of the internal agreement of observations made with astrolabes that have been temporarily placed there. These sites are at Briançon (Alpes), Font-Romeu (Pyrénées-Orientales) and Nice. The quality at all these sites is very variable with time so that it is difficult to arrive at a definite conclusion. Nevertheless, the results from these expeditions added to those from astrolabes in service elsewhere indicate that uneven country is an unfavourable factor, whilst nearness to the sea is favourable. These experimental observations are being continued and, in addition, the Gautier transit circle borrowed from Liège is being installed at Font-Romeu alongside the astrolabe so that the results from the two instruments can be critically compared. The transit circle will be used by observers from the Bordeaux Observatory for making observations in connection with the SRS project.

At Paris, Mlle Débarbat has investigated the possibilities of observing the planets with a Danjon astrolabe (16, 17). The results are very encouraging and seem to be of the same precision as for stellar observations. The positions found for Mars in 1963 are in good agreement with the Washington meridian observations. Several observatories have agreed to take part in a special series of planetary observations, particularly of Jupiter.

At the Cape, Dr Thomas is making a design study of an astrolabe in which the prism is replaced by a pair of plane mirrors in the hopes that

1. Such an instrument would give greater stability of the effective altitude of observation when the ambient temperature is changing;
2. The mirror angle can be chosen to make the instrumental almucantar any convenient altitude, e.g.  $50^\circ$ ;
3. With the limitation on the size of the prism removed, there is the possibility of constructing a larger instrument capable of reaching fainter magnitudes.

The aperture of the instrument for which the design study is being made is 25 cm which should enable it to reach two magnitudes fainter than the standard Danjon astrolabe.

#### SUGGESTED TOPICS FOR DISCUSSION

1. The results of the AGK<sub>3</sub> and AGK<sub>3R</sub> projects.
2. Progress with the SRS project.
3. The desirability of obtaining a homogeneous photographic cover of the southern hemisphere to supplement the SRS programme. (W. Dieckvoss).
4. The desirability of moving further transit circles to the southern hemisphere. (J. Dick).
5. Methods of using astrolabe results for the correction of fundamental catalogues and, in particular, the systematic correction to the FK<sub>4</sub> system implied by the preliminary discussions of astrolabe results. (D. V. Thomas).
6. Other evidence on the accuracy of the FK<sub>4</sub> system.
7. The desirability of some sort of uniformity about the presentation of the discussion given

in the introduction of meridian catalogues. (V. Maître as a result of a conversation with W. Fricke).

8. The desirability of meridian circle observers publishing the average apparent magnitude of stars as they appear during observation in order that magnitude effects can be properly evaluated. (G. van Herk).
9. Desiderata for future meridian circle observations.
10. New instrumental methods and techniques. (P. Sémirot).
11. The possibilities of making accurate astrometric measures from artificial satellites. (P. Lacroute who points out that the angle between two stars can be measured with an accuracy of  $0''.01$ , or less, provided that the angle in question is within  $15'$  of a given reference angle and that the satellite is not oscillating more quickly than once in ten seconds.)
12. The design of new wide angle objectives for astrometric purposes and their performance in use. (W. Dieckvoss).
13. A critical survey of the methods of reduction of co-ordinates measured on plates, with particular attention to those methods using field overlaps to reduce large regions simultaneously. (W. Dieckvoss).
14. The desirability of setting up one or more centres for the automatic measurement of large numbers of plates. (W. Dieckvoss).
15. The desirability of the compilation of a 'General Catalogue of Stars to the Ninth Magnitude' as suggested by Brouwer and as partially accomplished by the Smithsonian Astrophysical Observatory (3). (W. Dieckvoss).

R. H. STOY

*President of the Commission*

#### REPORTS OF THE WORKING GROUPS

##### *Photograph Catalogues of Stars to the Ninth Magnitude*

At Bergedorf the AGK2 has been reduced afresh in the FK4 system after the application of appropriate systematic corrections to the original rectangular co-ordinates measured at Bergedorf and Bonn. Also completed there is a preliminary version of the AGK3 based on a preliminary AGK3R provided by the Washington U.S. Naval Observatory. The Bergedorf Observatory is willing on request to provide transcripts from the magnetic tapes for the positions and proper motions of selected group of stars.

Part of the AGK2 and AGK3 data was sent to P. Lacroute who applied his method of reducing overlapping fields to the polar cap north of  $+40^\circ$  declination and derived plate constants for both the 1930 and the 1958 epochs.

The fifth volume of the Cape Photographic Catalogue for 1950.0, which covers the zone between  $-64^\circ$  and  $-80^\circ$ , has been published (69) while the sixth, and final, volume, which covers the sky south of  $-80^\circ$ , is ready for publication.

The Yale Observatory work on the zones between  $-30^\circ$  and  $-90^\circ$  continues. H. K. Eichhorn has concentrated on the zone  $-70^\circ$  to  $-90^\circ$  using measures of plates taken by H. Wood in Sydney. Together with C. F. Lukac of the U.S. Army Map Service, he has worked out procedures for the simultaneous reduction of large areas using overlaps of neighbouring plates.

W. DIECKVOSS



*International Reference Star Programs*

**AGK<sub>3</sub>R Program.** By late 1964 all observatories except Babelsberg, which did not complete its commitment, had sent the results of their observations to the U.S. Naval Observatory for the compilation of a catalog of final positions of the reference stars. With the exceptions of Heidelberg and Strasbourg, which sent mean results for each star, all other observatories sent individual results as recommended by Resolution No. 5, adopted by Commission 8 during the Berkeley Meeting of the IAU, 1961.

The intent of Resolution No. 5 was to permit a night-by-night reduction of the observations to the FK<sub>4</sub> and to enable other analyses of the observations to be carried out in detail. The wisdom of this Resolution, as it worked out in practice, is now questioned. The writer is firmly convinced that the final catalog would have been essentially as accurate and much simpler to compile if each observer had completely reduced his own observations before forwarding them to Washington. Too much time had to be spent in transferring the voluminous data to punch cards and in correcting thousands of errors by correspondence.

All observations have been reduced to the FK<sub>4</sub> on a night-by-night basis whenever possible. Clamp differences have been derived and applied where they seemed to be necessary.

In the course of deriving night corrections and in studying their effect on the AGK<sub>3</sub>R stars, the mean error of a single observation was estimated in one or more ways for each observatory that had sent individual results. Corresponding mean errors for Heidelberg and Strasbourg were estimated by other methods. The resulting mean errors are shown in Table 1. The mean errors from the FK<sub>4</sub> stars reflect the fact that the parameters for the nightly reductions were based on them. With the exception of the Pulkovo declinations, the mean errors from different data for an observatory are in fairly satisfactory agreement.

Systematic differences and the relative weights of results from different observatories are now being derived.

**Table 1. AGK<sub>3</sub>R Program: Internal Mean Errors of a Single Observation**

Observatory	AGK <sub>3</sub> R STARS				FK <sub>4</sub> STARS	
	with 2 obs'ns		with 4 obs'ns		many obs'ns	
	$\xi_\alpha \cos \delta$	$\xi_\delta$	$\xi_\alpha \cos \delta$	$\xi_\delta$	$\xi_\alpha \cos \delta$	$\xi_\delta$
Bergedorf	$\pm 0^s.016$	$\pm 0^s.42$	$\pm 0^s.---$	$\pm 0^s.---$	$\pm 0^s.017$	$\pm 0^s.38$
Bordeaux	.018	.34	.018	.33	.016	.29
Greenwich	.019	.45	---	---	.019	.43
Heidelberg	.017	.40	---	---	---	---
Nicolaiev	.020	.31	---	---	.016	.30
Ottawa	.025	.44	---	---	.023	.43
Paris	.016	.37	.016	.34	.014	.31
Pulkovo	.016	.61	---	---	.012	.44
Strasbourg	.014	.33	.014	.33	---	---
USNO 6-inch	.017	.32	---	---	.014	.27
USNO 7-inch	.013	.24	---	---	.012	.21

**SRS Program.** Table 2 shows the status of the SRS program as of 1 July 1966.

Table 2. Status of the SRS Program—1 July 1966

Observatory	Zone	Commitment		Date Started		Completed	
		stars	obs'ns	mo.	yr.	obs'ns	red'ns
Abbadia	+ 5° to - 15°	1 560	4	4	62	84%	90%
Bordeaux	+ 5 to - 15	1 560	4	6	62	72	100
Bucharest	+ 5 to - 10	1 176	4	7	62	96	29
Nicolaiev	0 to - 20	5 984	2	3	64	100	25
San F'ndo	- 10 to - 30	3 709	4	3	63	33	53
Tokyo	- 10 to - 30	3 560	4	3	63	73	70
Cape	- 30 to - 90	10 082	4	4	61	35(1)	90
Santiago-Pulkovo	- 25 to - 90	11 496	4	1	63	81(2)	20

- (1) All observations of the reference stars in the zone - 40° to - 52° have been completed and a preliminary catalog of the results has been prepared. Observations in the zone - 30° to - 40° commenced during March 1966.
- (2) The zone - 47° to - 90° will be completed by the end of the year.

It is expected that the Hamburg-Bergedorf meridian circle will be shipped to Perth, Australia during March or April 1967. The U.S. Naval Observatory's seven-inch transit circle is expected to be installed at El Leoncito, Argentina, the site of the Yale-Columbia Southern Observatory, during the latter part of 1966 or early 1967. Both of these instruments will be engaged in programs of fundamental work and in the observation of the southern reference stars.

The U.S. Naval Observatory has computed over 134 000 apparent places, 60 000 refractions and 57 000 m, n and c reductions for observations made in connection with the SRS program.

*Double Star Program.* A revised list of 2292 double stars that might be troublesome to measure on photographic plates was compiled at the U.S. Naval Observatory from the Index Catalogue of Visual Double Stars, 1961-0, by Hamilton M. Jeffers and Willem H. van den Bos with Frances M. Greeby, *Publ. Lick Obs.*, 31, Parts I and II.

The following criteria, based on recommendations of the Double Star Committee appointed by Commission 8 during the Hamburg Meeting of the IAU, were used in the selection of double stars.

- (a) The magnitude of the brighter component shall lie within the limits,  $6^m.0 < m_B < 9^m.0$ .
- (b) The magnitude difference between the components shall lie within the limits,

$$0^m.0 < (m_F - m_B) < 4^m.0.$$

- (c) The separation,  $s$ , of the components shall lie within the limits,  $2''.0 < s < d$  where,  $d = 29.0 - (m_B + m_F)$ .
- (d) The brighter component must have a Durchmusterung number.

Interested observers may obtain copies from the U.S. Naval Observatory if requested before 1970.0.

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APPENDIX. REPORT ON THE PROBLEMS OF POSITIONAL ASTRONOMY  
STUDIED IN THE U.S.S.R (JULY 1963-AUGUST 1966)

1. *Studies in accordance with recommendations of the IAU and other international organizations*

(a) *The southern reference stars (SRS).* The observations of the SRS in the declination zone  $-5^{\circ}$  to  $-20^{\circ}$  have been completed at the Nikolayev Observatory by means of the Repsold Meridian Circle (observers: V. V. Konin and E. V. Khrutskaja). The reduction of observation is being carried on intensively and nearing completion. A semi-automatic electronic measuring machine is used for measurements of the films with the images of circle readings (38).

The observations of 13 489 stars (SRS, BS and DS) in the declination zone  $-25^{\circ}$  to  $-90^{\circ}$  are being continued at the Cerro-Calan Observatory by the Chilean and Soviet astronomers. More than 60 000 observations were obtained by the end of 1965 (observers: C. Anguita, V. S. Bedin, M. S. Zverev, G. Carrasco, P. Loyola, A. A. Naumova, D. D. Polojentsev and T. A. Polojentseva).

(b) *Bright stars (BS).* The observations of bright stars are being made in Chile (see point (a)) and also in the Kiev University Observatory (observers: A. G. Gregul, V. K. Drofa and N. A. Chernega) in the declination zone  $-10^{\circ}$  to  $+90^{\circ}$ . Altogether 7500 observations have been already obtained. In the Tashkent Observatory the bright stars are observed in the right ascensions only ( $-20^{\circ} < \delta < 90^{\circ}$ ). The observations in the declination zones  $-20^{\circ}$  to  $-10^{\circ}$  and  $0^{\circ}$  to  $+10^{\circ}$  were completed and published (124, 125). In total the work will be completed in 1967.

(c) *The stars of the PZT and Latitude programs.* The observations of the latitude stars and stars in the PZT programs are being made with the vertical circle at Pulkovo (observers: G. S. Kossin and B. K. Bagildinsky) and with the meridian circle at the Engelhardt Observatory. Determinations of the right ascensions and declinations of the PZT stars and also the declinations of the latitude stars were commenced at the Sternberg Institute with the new meridian circle. The determination of the declinations of the Pulkovo zenith stars in the program of observations with the zenith-telescope ZTL-180 are being made at the Odessa Observatory (observer: L. A. Klepikova).

(d) *The KSZ program.* The reduction of observations of the KSZ and FKSZ stars are being continued. The catalogues of the Kiev (107), Engelhardt (114), Tashkent (119) and Odessa (98) Observatories have been published. The following editions have been prepared for publication: (1) L. F. Gorel, 'The Catalogue of 2600 Stars (KSZ) in the Declination Zone  $-5^{\circ}$  to  $-20^{\circ}$ , compiled from Observations with the Meridian Circle at Nikolayev'; (2) B. V. Novopashenny, 'Catalogue of Right Ascensions of 2963 KSZ Stars in the Declination Zone  $-5^{\circ}$  to  $-25^{\circ}$ , compiled from Observations at Odessa'.

A re-reduction of the catalogues of the KSZ and FKSZ stars in the FK4 system are being

made at the Pulkovo, Kiev and Engelhardt observatories (zone  $-10^{\circ}$  to  $+90^{\circ}$ ). The compiling of the general KSZ catalogue in the declination zone  $+90^{\circ}$  to  $-30^{\circ}$  was commenced at Pulkovo, all the obtained observations being used.

The observations of the selected minor planets according to the KSZ program were made at Pulkovo, Moscow (Sternberg Institute), Golosseyevo, Tashkent and Nikolayev. A part of these observations is published (18, 20, 21, 127-133). The observations of minor planets, made at the Cape Observatory during 1956-63 were reduced and published at Pulkovo (19, 128).

The photographic observations of the first epoch of 205 areas with the galaxies and 240 areas with the fundamental KSZ stars in the declination zone  $+90^{\circ}$  to  $-25^{\circ}$  have been completed. These observations were made at Pulkovo, Moscow (Sternberg Institute), Golosseyevo and Tashkent.

### II. *Absolute determinations. Observations of the solar system bodies*

At Pulkovo the compiling of the absolute catalogues of right ascensions of 507 bright and 522 faint stars (large transit instrument) and declinations of 542 bright and 531 faint stars (vertical circle) have been completed (33, 34, 61).

The catalogue of right ascensions as regards to  $\Delta\alpha_0$  is close to N30. A comparison of declinations of the new Pulkovo catalogue with the fundamental systems shows that it is also in good agreement with N30.

The mean error of one observation is represented by the formula

$$\sigma(z)^2 = (0^{\circ}34)^2 + (0^{\circ}17 \operatorname{tg} z)^2$$

The absolute declinations of 1181 bright stars (in the declination zone  $+90^{\circ}$  to  $-30^{\circ}$ ) and 611 faint FKSZ stars (in the declination zone  $+90^{\circ}$  to  $-25^{\circ}$ ) were determined at Golosseyevo with the Vanschaff vertical circle. The catalogue is being prepared for print.

The absolute determinations of the declinations of 1443 bright stars of the southern sky ( $-90^{\circ}$  to  $30^{\circ}$  of declination) made by the Chilean and Soviet astronomers at the Cerro-Calan Observatory are nearing completion. The observations are being made by means of the photographic vertical circle (PVC), designed by M. S. Zverev. The mean error of one observation is  $\pm 0^{\circ}25$ .

The construction of the large transit instrument for absolute determinations of the right ascensions of the southern sky stars will be completed at Pulkovo in the near future. By the end of 1966 this instrument will be forwarded to Chile.

The regular meridian observations of the Sun, Moon and major planets were made at Pulkovo, Nikolayev, Moscow (Sternberg Institute), Tashkent, Kharkov and Engelhardt Observatory (12, 13, 35, 43, 44, 52, 53, 62-67, 86).

The photographic observations (17, 51) of the major planets (except Mercury) were made at Nikolayev.

### III. *Separate series of observations and their reduction*

The compiling of three catalogues of the absolute right ascensions of about 800 stars (55, 57, 59) has been completed at Pulkovo. They are based on the observations made during 1957-63 with three photoelectric transit instruments of the Time Service. The compiling of the general catalogue of right ascensions of the stars in the U.S.S.R. Time Service program is nearing completion. This catalogue is based on more than 150 000 observations.

The systematic observations with the Danjon astrolabe are in progress at the Pulkovo Observatory. The reduction of two annual series (1963-64 and 1964-65) has been completed.

A reduction of the absolute observations obtained by M. A. Grachev during 1909–17 has been completed at the Engelhardt Observatory. The Catalogue of 2500 stars has been compiled.

The compiling of the catalogue of right ascensions of the stars in the declination zone  $+ 90^\circ$  to  $+ 70^\circ$  has been completed at the Kiev Observatory (112). For 79 stars of this catalogue the proper motions were determined (113). Each  $0.5^\circ$  division of the meridian circle of the Kiev Observatory was investigated using the photographic device (111).

Three catalogues of right ascensions of about 200 stars in the U.S.S.R. Time Service program were compiled from the observations with two instruments of the Time Service in Tashkent. One of them was published (120); the others are in print.

IV. *Instruments*

An original device for photographing the circle was constructed by A. M. Stafeev at the Odessa Observatory. A detailed investigation of the errors of the circle readings through  $10'$  were completed.

A transistor photoelectric device for registering star transits, permitting to observe the faint stars, was designed at Nikolayev by M. I. Ilkiv.

The investigation of the L. A. Sukharev horizontal meridian circle is being made at Pulkovo. Preliminary observations of the stars in  $\alpha$  have been started.

A double-meniscus astrograph ( $D = 70$  cm;  $f = 2.2$  m), made in the U.S.S.R., for the photographic observations of galaxies and fundamental stars is mounted in Chile.

v. *Conferences*

The 17th Astrometrical Conference was held at Pulkovo during 31 May–3 June 1966. Altogether more than 100 astronomers, representative of 26 astronomical institutions of the U.S.S.R., German Democratic Republic, Mongolia, Romania and Yugoslavia participated. Two main problems were discussed: (1) on the compiling of the general catalogue KSZ and (2) on the constructing of new astrometrical instruments. 'Transactions' of the conference are being prepared for print.

A. A. NEMIRO  
*Vice-President of the Commission*

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