

8. POSITIONAL ASTRONOMY (ASTRONOMIE DE POSITION)

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ORGANIZING COMMITTEE: C. A. Anguita, B. L. Klock, P. Lacroute, A. A. Nemiro, J. L. Schombert, R. H. Tucker, J. E. B. von der Heide, H. W. Wood, H. Yasuda.

I. INTRODUCTION

We pay tribute to the memory of M. G. Pereira de Barros, who died on 31 January 1971, and of Pierre Sémirot, who died on 30 January 1972. Both astronomers contributed greatly to our subject, in addition to their researches in other fields of astronomy. In July 1971 F. P. Scott resigned as Chairman of the SRS Committee of Commission 8 after his retirement from the position as Director of the Seven-Inch Transit Circle Division at the U.S. Naval Observatory. Much of the progress of the SRS programme is due to the assistance and guidance which Mr Scott has generously given to many participants in the programme. The Commission has expressed its high appreciation and gratitude for his admirable work and fine collaboration. Upon request of the Commission, J. L. Schombert, Director of the Southern Transit Circle Division of the U.S. Naval Observatory, has taken over the Chairmanship of the SRS Committee.

The activity of the Commission has been furthered by numerous letters of the members in response to Circular Letters of the President and Vice-President. A 'Study Group on Astronomical Refraction' has been formed with G. Teleki as Chairman (see section VI) after an exchange of views with various members of the Commission. The IAU Colloquium No. 20 'Meridian Astronomy' held in Copenhagen 25–28 September 1972 under the Chairmanship of G. van Herk was attended by 32 persons, mostly members of the Commission. At the Colloquium resolutions were adopted and submitted for consideration and endorsement by Commission 8 at the XV General Assembly (see section VII).

In the following report the names of the persons who provided the basis of the information are given in parentheses; verbal presentation of communications has been avoided for reasons of conciseness and smoothness. A. A. Nemiro has kindly summarized the contributions of astronomers of the Soviet Union to each section, and J. L. Schombert has edited a summary report on the SRS Programme. Whenever possible, references of papers have been given by 8 figures denoting the serial number of the paper in *Astronomy and Astrophysics Abstracts*; the first two figures denote the volume of the Abstracts.

II. INSTRUMENTS, ACCESSORIES, OBSERVING TECHNIQUES

At the U.S. Naval Observatory the Automatic Transit Circle (ATC) was installed in 1972. It is currently being adjusted by the manufacturer, Farrand Optical Company, Inc., and should become operational in 1973. After an exhaustive performance evaluation programme in Washington the instrument is expected to be re-located at the U.S. Naval Observatory Flagstaff substation. Two new photodiode circle scanning systems have been received. One system is installed on the ATC and the other on the six-inch transit circle. These systems will enable preliminary positions of observations to be determined almost immediately following an observing tour. An extensive investigation into the theoretical as well as the practical analysis of Inductosyn systems has been initiated. The results will be published upon completion of the study. The six-inch transit circle received a complete re-furbishment in 1972. A new temperature-compensated objective was obtained and is being tested (B. L. Klock).

At the Royal Greenwich Observatory the circle-reading cameras of the Cooke Transit Circle have been fitted with graticules of a new design. The two fiducial marks on the graticule are in the form of two parallel interrupted lines, each consisting of four or five segments 1 mm long separated by gaps of 1 mm. The segments of one line are opposite to the gaps in the other, so that a circle division that happens to be nearly or exactly coincident with one of the fiducial marks can still be measured in the gaps of that mark, at the same height as the segments of the other fiducial mark. Preparations are being made to digitise the RA and ZD micrometers. The RA drive is being re-designed to include a stepping motor mounted on the telescope. The possibility of providing an electronic moiré-fringe arrangement for reading the circle is being investigated. Preliminary studies are in hand for the design of a transportable automatic transit circle to be used at Herstmonceux and at the SAAO observing station at Sutherland. This instrument will serve to replace the Gill Transit Circle at Cape Town, which is nearing the end of its active life, and which would not be suitable for transfer to Sutherland. The printing chronograph of the Gill Transit Circle at the Cape has been replaced by a solid-state punching and indicating chronograph. At Herstmonceux, full use is made of the computer in daily editing and monitoring of the observations. Approximate values of collimation, level, azimuth and clock corrections are adopted fortnightly, and this enables the acceptance limit for O-C in RA to be reduced to 5". A magnetic disc file carries the list of dates of accepted observations for each star in the observing list, and can be used to provide counts to assess the progress of the observing programme at any time. Close collaboration between the Meridian Departments at Herstmonceux and the Cape, including personal visits in each direction, has led to rapid progress in transferring the Cape reductions to the Herstmonceux computer. A ledger of Cape observations of FK4 stars has been compiled and is being used for determining corrections to individual places of Cape Azimuth and Clock stars (K. C. Blackwell, R. H. Tucker).

For the establishment of an astrometric Observatory in France the decision on the site was made on the basis of data gathered at six stations. The data include information on meteorologic qualities, stellar images, and the accuracy of observations carried out with Danjon's Astrolabe. The data were analysed by Laclare (08.041.020). The site will be on the Plateau de Calern, north of Grasse (Alpes-Maritimes). The project of the new institution has been described by Barlier *et al.* (08.009.014), and it has been approved as 'Centre d'Etudes et de Recherches Géodynamiques et Astronomiques', abbreviated CERGA. The domain of CERGA will include astrometry, celestial mechanics, and certain branches of astronomy, geophysics, and geodesy. At the moment, its equipment includes a Danjon Astrolabe and a time station with caesium clock. It is planned to get equipment for meridian astronomy, astrography of large fields, long-focus astrography, observations of satellites (laser, Doppler), laser telemetry, long-base-line interferometry, clinometry and gravimetry (J. R. Lévy).

At the Bordeaux Observatory a tracking photoelectric micrometer was constructed and mounted on the meridian circle in 1971. It allows the automatic and simultaneous determination of the transit time and declination of stars down to magnitude 9.2. This micrometer has a double-slide right ascension carriage moved by a high accuracy micrometer screw and a declination carriage mounted on the first one. The image position analyser is fixed on this second carriage. The sensor is based on a half-disk light modulator (rotating knife-edge) and a high sensitivity photomultiplier. The photoelectric signal, sinusoidally modulated, is sent to two synchronous detectors which elaborate two independent error signals for the control of the carriages. The right ascension servo is classical but the declination servo is a non-linear system. The mechanical design is complex and was machined with the highest precision, especially the rotating knife-edge. The total backlash is less than one micron. The transit time is given by electric contacts and a digital chronograph. The position of the declination carriage is given by a displacement transducer and a digital voltmeter. The data are transmitted to a digital recorder or a high speed tape puncher. From about 1500 differential observations of FK4 stars ($0^\circ < \delta < +80^\circ$) the mean square error for one observation (reduced to the equator) is ± 0.007 in RA and ± 0.20 in Dec; the same internal accuracy is obtained with faint stars ($m < 9.2$). This photoelectric tracking micrometer is now employed for

regular observations of the International Northern PZT Programme (Y. Requième) – At Besançon a new photoelectric micrometer with a grating in the focal plane (utilizing the principle of Høg's design) has been investigated. The micrometer is fully automatized (V. Maitre) – A new Large Transit Instrument (12 cm, 129 cm focal length) was mounted at the Cagliari Astronomical Observatory (Italy). The instrument is equipped with a new double micrometer (drive in Dec and RA); a photoelectric micrometer is planned. Observations will include FK4 and FK4 Sup stars, planets, minor planets, and stars of special interest (E. Proverbio) – At the Grubb-Parsons Meridian Circle of the Instituto y Observatorio de Marina, San Fernando (Cádiz), a shaft encoder for the digital readout of the declination micrometer was installed. A system for digital readout of the circle similar to that of the Copenhagen Observatory is being planned. The chronographic registration at the Meridian Circle and Astrolabe has been improved (L. Quijano).

At the Pulkovo Observatory the influence of aberrations, decentring of the lenses and temperature gradients on the results of astrometrical observations was investigated (*Trudy 18th Astrometr. Conf. U.S.S.R.*, p. 330, 1972). On the basis of photoelectric observations of 188 FK4 stars in the -10° to $+90^{\circ}$ declination zone with the Sukharev horizontal meridian circle a catalogue of right ascensions has been compiled. The mean error of one observation is ± 0.011 . The systematic corrections to the FK4 were deduced using the 'quasi absolute method' suggested by M. S. Zverev. The results obtained from the observations with the northern and southern tubes are in good agreement (*Trudy 18th Astrometr. Conf. U.S.S.R.*, p. 158, 1972). At the Odessa meridian circle and Nikolayev Freiberg transit instrument motor-driven micrometers for observations of right ascensions have been installed (*Trudy 18th Astrometr. Conf. U.S.S.R.*, p. 165, 1972). An original device for the determination of personal errors in observations of declinations has been built at the Nikolayev Observatory (*Trudy 18th Astrometr. Conf. U.S.S.R.*, p. 185, 1972) (A. A. Nemiro).

L. A. Mitić and his collaborators at the Belgrade Observatory continued work at the installation of the Large Transit Instrument (Askania, 19 cm aperture, 257.8 cm focal length). The work concentrated on the construction of meridian marks as reported at the XIV IAU General Assembly. Pillars are being protected against atmospheric and underground water, and vacuum tubes are being installed between the marks and the instrument for eliminating refraction from the readings following a suggestion by van Herk and de Munk. The work was supported by the Pulkovo Observatory, particularly, by A. A. Nemiro. Teleki (06.032.024) has examined, by means of the auto-collimation method, the stability of the tube's optical and mechanical system of the large vertical circle and has found changes with the temperature mainly. Jointly with M. Mijatov, he has investigated the effects of deficiencies of the horizontal axis on zenith distance measurements, and jointly with Alpár (04.046.017) he has published remarks on the calibration and use of precise levels.

At the Porto Observatory, Portugal, work has been continued to put the Mirror Transit Circle in operation. For eliminating one of the main difficulties, the instability of the mirror, the mirror support was modified, however, so far without satisfactory result (J. S. P. Osório) – At the Bucharest meridian circle, a device was installed for printing the time of each micrometer declination record. Rusu (07.032.028) published the results of an investigation of the flexures of the tube and circles of the Bucharest meridian circle (E. Marcus).

Høg (05.041.043) has proposed a new type of a meridian circle with very small flexure (0.02). A design study for this instrument is in press. He has also completed "A design study of a multislit micrometer and a semiautomatic meridian circle" which is available on request. Høg expects that observations of stars down to about magnitude 12 and of objects of the solar system may become possible at a conventional meridian circle of 20 cm aperture. Another design study for a new automatic meridian circle is in progress at the Tokyo Astronomical Observatory.

At the Hamburg Observatory a new zone-astrograph (21.3 cm aperture, 206 cm focal length) built by Zeiss-Oberkochen was installed. The instrument has a five-element objective corrected for the yellow spectral region; it will be used with a yellow-filter fixed near the focal plane. The astrograph will come into operation by the end of 1972 (C. de Vejt) – Pilowski (07.008.065) has developed a transportable Zenith Camera for use in the open field; it allows a latitude determination

within half an hour with an accuracy of 0.1 or better. Several of these transportable cameras may contribute to the determination of zonal errors of the fundamental catalogue in both co-ordinates over the whole sphere; the cameras may also contribute to determine the equator point, if the observations are being made at well determined absolute latitudes. For transportable transit instruments K. Pilowski and J. Winter have designed and successfully tested an 'optische Kippachse' (hingepin) consisting of mirror, optical double-micrometer and automatic levelling for the elimination of effects of irregularities of the pivots on inclination and azimuth and for the determination of the inclination itself.

A new meridian circle (19 cm aperture, 240 cm focal length) built by Askania was mounted at the Observatorio Cagigal, Venezuela. For starting an observing programme the Observatory needs assistance by experienced observers in getting the meridian circle into good operating conditions. There are young astronomers in Caracas who can continue the programme once it is established (F. P. Scott) – At the La Plata Observatory the meridian circle, on loan from the Lick Observatory, has not yet been installed. The rebuilding and modernization of the instrument will be finished in 1972/73; it shall be used for observations corresponding to the SRS programme (S. J. Slaucitas).

The Potsdam-Babelsberg Meridian Circle was examined by H. U. Sandig. Micrometer, pivots and circle turned out to be in good condition. The observations of 4 Küstner series gave very good results in RA and Dec. No decision has yet been made on future work with the instrument. – At the Pulkovo Observatory the flexure of the Ertel vertical circle in day-time was investigated. The observed declinations of the Sun, planets and stars became more consistent with ephemerides after correcting for the new values of flexure (*Trudy 18th Astrometr. Conf. U.S.S.R.*, p. 198, 1972).

III. FUNDAMENTAL REFERENCE SYSTEM

At many observatories stars of the FK4 and the FK4 Sup have been observed either by means of absolute techniques or differentially. The observations carried out with the aim of contributing to the improvement of the fundamental system and others in which the FK4 stars serve as reference system are of importance for a revision of the FK4. It deserves mentioning that from observations within reference star programmes the observers should derive corrections to the FK4 positions without exception and publish the results. For the determination of the equinox and equator, observations of the Sun, major planets, and minor planets are still required. As far as minor planets are concerned the work by Jackson (04.041.026) has indicated that observations clustering around opposition and the time of eastern elongation are not sufficient. Required are observations, if possible, from quadrature to quadrature; this aim can be reached in the future with instruments which are able to observe down to a fainter magnitude limit.

At Herstmonceux regular observations of the Sun, major planets, the four brightest minor planets and all FK4 stars north of -31° declination have been continued. At the Cape the minor planets are observed when available. Occasional observations of the major planets are taken. Herstmonceux observations of Sun and planets from 1957 to 1971 have been reduced, and the results should be published (on the system of FK4) towards the end of 1972. RA observations of 375 FK3 stars, made with the Cooke Transit Circle while it was located at Greenwich, 1937–1940, have been formed into a catalogue and prepared for publication. In due course other 1950.0 catalogues will be prepared from observations made with the Airy Transit Circle at Greenwich from 1940 to 1954, and with the Cooke Transit Circle at Herstmonceux from 1957 onwards. Investigations are continuing with a view to defining the fundamental instrumental system of the Herstmonceux observations (K. C. Blackwell, R. H. Tucker).

At the U.S. Naval Observatory the Washington 5₅₀ Fundamental Catalogue is being compiled and analyzed. It is expected to be ready for publication in 1974. Gauss (05.041.032) has completed an investigation on the right ascension system of six-inch transit circle catalogues (B. L. Klock) – The U.S. Naval Observatory seven-inch transit circle at El Leoncito, Argentina, in addition to its SRS differential work, has been taking all-night tours about once a week in which all FK4

and FK4 Supplement stars between $+30^\circ$ and -70° SP are included. Mark lenses were installed in March 1970 and the marks have been observed since that time (J. L. Schombert).

Observations of absolute declinations of FK4 stars, major planets, and of the four brightest minor planets have been continued with the vertical circle of the Munich Observatory in Munich (F. Schmeidler) – At the University Observatory in Vienna a small modern Transit Instrument (Ap 70/645) was used for differential observations of 200 FK4 Sup stars. Many of these stars indicate errors of the catalogue positions in right ascension of the order of $0^{\circ}03$ to $0^{\circ}1$. A recently purchased Zenith Telescope (Zeiss-Jena 135/1750) which will be altered into a vertical circle shall also serve for the observation of declinations (P. Jackson).

At the Tokyo Astronomical Observatory, regular observations of the Moon, planets, and of the four brightest minor planets referred to the FK4 system have been continued. The results of the observations of bodies of the solar system from 1963 to 1967 were published by Yasuda *et al.* (06.041.003). The meridian observations of the Moon made at Tokyo and Washington from 1952 to 1967 were examined by Yasuda and Miyauchi (05.094.079); corrections to the lunar elements and to the fundamental system were determined. Yasuda (07.041.018) has proved the possible existence of $\Delta\alpha_x$ in the FK4 system by applying his method of deriving a right ascension system to the observations made at Tokyo within the SRS programme; he confirmed the results he had previously obtained from observations of minor planets. Especially in the declination zone from -25° to -37° the α_x -system deviates from the FK4 between $+0^{\circ}009$ (5^h) and $-0^{\circ}013$ (20^h). According to S. Isobe the error of the combined result of observations of FK4 stars with 10 meridian circles within the AGK3R and SRS programmes is $\pm 0^{\circ}004$, $\pm 0^{\circ}1$ (H. Yasuda).

Mancuso *et al.* (08.041.005) have analysed time observations carried out 1967/68 with the Döllén method for the determination of corrections $\Delta\alpha_x$ and $\Delta\alpha_\delta$ to the FK4. The Instituto y Observatorio de Marina in San Fernando (Cádiz) has completed its first programme of observations of FK4/FK4 Sup stars with the astrolabe in 1971; the reductions are in progress. The observations of a new list of FK4/FK4 Sup stars have been started (L. Quijano) – Corrections to FK4 star positions have been derived from more than 40000 individual observations carried out since 1968 with the Danjon Astrolabe at San Juan, Argentina (J. A. López) – In Potsdam the discussion of astrolabe observations from 1962 to 1970 for the derivation of corrections to the FK4 is nearly finished (H. U. Sandig) – The analysis of the 1965–69 Cape astrolabe observations has made slow progress. Preliminary zenith-distance corrections have now been derived for the standard stars in each group; closing errors have been obtained, but not yet fully investigated, for the time and latitude observations; investigation of the observed prism angles is proceeding. The final results of the observations may be available by the end of 1973 (D. V. Thomas) – The Southern Astrometric Station of the La Plata Observatory in La Leona has completed observations of absolute declinations of southern FK4 stars in 1970; the reductions are not yet finished. From 1971 absolute declinations of FK4 Sup stars have been observed at the Station. At La Plata, observations have been made with the Transit Instrument in Küstner series; the aim is the derivation of corrections, $\Delta\alpha_x$ and $\Delta\alpha_\delta$ (S. J. Slaucitas) – By the end of 1971, the Hamburg Expedition team had returned to Germany from Perth, Western Australia. The Hamburg meridian circle and its electronic and recording equipment will, however, remain at the Perth Observatory for a further few years. With this instrument differential observations of FK4/FK4 Sup stars and planets were started in 1972. Day-time observations including observations of the Sun and Moon will also be attempted (B. J. Harris, I. Nikoloff).

At Pulkovo the corrections $\Delta\alpha_\delta$ have been determined to the FK4 system in the southern hemisphere from observations of reference stars and zone observations in the SRS programme. The results obtained from zonal observations are in good agreement with those derived from the series of reference stars. Results were published by Anguita *et al.* (05.041.021), and attention is drawn to other papers in *Izv. Glav. Astron. Obs. Pulkovo* No. 189–190, 1971. The catalogue of right ascensions of 671 bright FK4 stars in the zone $+40^\circ$ to -90° has been compiled on the basis of observations (1963–1964) with the Zeiss transit instrument at the Cerro-Calán Observatory. This catalogue is independent with respect to $\Delta\alpha_x$ in the zenith zone of Cerro-Calán. A comparison

of the catalogue with the FK4 confirms that the FK4 in the southern hemisphere has considerable $\Delta\alpha_5$ errors, as it was found from the SRS observations (*Trudy 18th Astrometr. Conf. U.S.S.R.*, p. 84, 1972) – The general catalogue of right ascensions and proper motions of 807 stars compiled from 185000 observations in the Time Service programme has been published by Medvedeva and Nemiro (07.112.005). The catalogue is being used for time determinations at the stations of the U.S.S.R. Time Service (A. A. Nemiro).

C. Anguita has summarized in some detail the results of ten years of cooperation between Soviet and Chilean astronomers under an agreement between the U.S.S.R. Academy of Sciences and the University of Chile. The following three catalogues of right ascensions have been compiled:

(1) The SPF-1 Catalogue by Anguita *et al.* (05.041.021) contains the results of observations of Küstner series of the FK4 stars with the Repsold Meridian Circle in the declination zone $+41^\circ$ to -90° (from -68° to -90° in lower culmination). 211 series of 6793 star observations were made from 1963 to 1968. The mean error of one observation reduced to the equator is $\pm 0^{\circ}020$ for upper culmination and $\pm 0^{\circ}022$ for lower culmination. The reductions were made using the quasi-absolute method proposed by Zverev (02.031.022). The SPF-1 catalogue will be published by the end of 1972 and is already available on punched cards.

(2) The SPF-2 Catalogue contains the results of observations of FK4 stars in zone observations of SRS stars with the Repsold Meridian Circle. The results are already complete in the declination zone -47° to -90° . 799 series of 15 160 FK4 star observations were made from 1963 to 1968 in this zone. The mean error is $\pm 0^{\circ}016$ for upper culmination and $\pm 0^{\circ}020$ for lower culmination. All the reductions were made in the FK4 system and in the instrumental system of the Repsold Meridian Circle.

(3) The SPF-3 Catalogue was derived by applying the quasi-absolute method to observations of a special programme with the Zeiss broken transit instrument. The programme was described by Loyola and Shishkina (*Izv. Glav. Astron. Obs. Pulkovo* No. 183, p. 25, 1968). The programme consisted of 726 stars from $+40^\circ$ to -90° including 666 FK4 stars. 42 stars with declination from -75° to -90° were observed in lower culmination.

After the Pulkovo Large Transit Instrument had been installed at the Cerro-Calán Observatory 463 series with a total of 40900 individual star observations were made from May 1969 to October 1970. Then the objective glass and the ocular were interchanged, and a new series of observations started in December 1970. Until September 1972 a total of 345 series with approximately 30000 individual star observations were made in the second position of the instrument. The programme will be continued in order to reach the same number of observations as were made in the first position of the instrument. The catalogue containing the observations in the first position of the instrument will be ready by the end of 1973. The Danjon Astrolabe operated at Cerro-Calán since 1965 under an agreement with the European Southern Observatory has been used for determining systematic and individual errors of the FK4. All suitable FK4 and FK4 Sup stars from -5° to -62° and brighter than magnitude 6.3 have been observed. A selection of 233 FK4 and 24 FK4 Sup stars of the zone is arranged in 11 groups of 28 transits distributed equally in azimuth. These are the 'standard groups' which will define the system for the Astrolabe Catalogue of Santiago. The remaining stars are observed in the 'catalogue groups' such that each star may be observed in both transits. The first series of 11 catalogue groups of about 300 stars was observed in 1967 and 1968, and the second series of about 200 stars in 1969 and 1970. In 1971 and 1972 the observations of some catalogue groups of both series were completed which had a rather low number of observations. First definitive results will be available in 1973 (C. Anguita).

At the Astronomisches Rechen-Institut, Heidelberg, preparations have been continued for an improvement of the FK4 and its extension to fainter stars. A survey of observational material has been made that was published after the completion of the FK4. The material is larger than one would expect: It consists of about 140 catalogues, photographic catalogues excluded; for 25 catalogues the authors claim that the observations were made by absolute techniques. When the survey will be finished, the list of catalogues relevant to the improvement and extension of the FK4 will be published with a request for comments and additions. Much of the material has still

to be punched before it can be analysed. Observatories are requested to facilitate the work by providing catalogues on punched cards. Assistance in punching has so far been offered by the U.S. Naval Observatory and the Centre de Données Stellaires, Strasbourg. A report on the organization of the project of the improvement of the FK4 and its extension, resulting in a new fundamental catalogue, the FK5, shall be presented at the XV General Assembly. It is expected that the project will take about 8 to 10 years for completion. A review on fundamental systems of positions and proper motions was published by Fricke (08.041.022).

IV. REFERENCE STAR PROGRAMMES

(a) *AGK3R Programme*

The U.S. Naval Observatory has distributed the catalogue of final positions to the Astronomisches Rechen-Institut, the Cincinnati Observatory and the Tokyo Observatory. Proper motions for the majority of the AGK3R stars are now being derived in Washington. It is planned that proper motions for stars with favorable observational histories between -5° and $+90^\circ$ will be derived first. The catalogues to be used have now been selected and are in machine readable form (J. L. Schombert) – From a comparison of seven meridian and photographic catalogues of circumpolar stars with the AGK3, Telnyuk-Adamchuk (06.041.005) has found that the system of coordinates and proper motions of the AGK3 in the circumpolar zone deviates essentially from the FK4 system (A. A. Nemiro).

(b) *SRS Programme*

J. L. Schombert, Chairman of the SRS Committee, reports: The status of the SRS Programme on 1 July 1972 is shown in Table 1. Final results have been received from Abbadia, Bordeaux and the Washington six-inch programmes. Observations have been completed at Bucharest, Nicolayev, Tokyo, Bergedorf (Bickley) and Santiago-Pulkovo. They are well advanced at the other

Table 1. Status of the SRS Programme – 1 July 1972

Observatory	Zone	Commitment		Date Started	Completed		Final Results Expected
		Stars	Obs'ns		Obs'ns	Red'ns	
Abbadia	+ 5° to - 15°	1560	4	62.3	100%	100%	1968.8
Bordeaux	+ 5 to - 15	1560	4	62.5	100	100	1970.5
Bucharest	+ 5 to - 10	1176	4	62.6	100	95.8	1975.0
Nicolayev	0 to - 20	5984	2	64.3	100	97	1973.0
San Fernando	- 10 to - 30	3709	4	63.3	95	90	1973.5
Tokyo	- 10 to - 30	3560	4	63.3	100	100	1972.7
USNO 6-in	+ 5 to - 30	{ 8706 1233 }	{ 2 4 }	66.5	100	98	1972.7
Bergedorf (Bickley)	+ 5 to - 90	20495	4	67.9	100	95	1974.5
Cape	{ - 30 to - 40 - 40 to - 52 - 52 to - 64 - 64 to - 90 }	10082	4	61.3	{ 100 100 65 0 }	{ 97 100 50 0 }	{ 1973.5 1966.0 1974.5 - }
San Juan	- 40 to - 90	7190	2	69.5	93.6	100	1973.5
Santiago- Pulkovo	{ - 25 to - 47 - 47 to - 90 }	{ 5992 5504 }	{ 4 4 }	{ 63.1 63.1 }	{ 100 100 }	{ 55 70 }	{ 1974.0 1975.0 }
USNO 7-in (El Leoncito)	{ + 5 to - 20 - 20 to - 75 - 75 to - 75SP }	{ 7683 12121 1382 }	{ 2 4 4 }	68.7	{ 83 95 87 }	62	1975.0

observatories. It is regretted that the Cape zone -64° to -90° will, in all probability, not be started. (It is probable that the instrument at the Cape will be taken out of service at the end of 1973). The U.S. Naval Observatory programme at El Leoncito, Argentina has progressed very well. For the period of this report, over 105000 observations of all stars were made and during one 12-month period, over 40000 observations were obtained. The U.S. Naval Observatory has made over 233000 apparent place, 130000 refraction and 156000 m , n , and c computations for participating observatories in the SRS Programme.

Additional information on work at the SRS Programme: A preliminary analysis of the observations made at Perth and a description of the techniques were given by Høg (07.032.031) – At Pulkovo the reduction of observations of the SRS and BS right ascensions in the zone -47° to -90° made with the meridian circle of the Cerro-Calán Observatory has been completed. The catalogue of 5513 SRS and 829 BS is being prepared for publication in the system of the instrument (A. A. Nemiro) – The observations at the Chilean commitment in the zone -25° to -47° (5992 SRS and 805 BS stars) have been carried out with the Repsold meridian circle, and the reductions are still going on. G. Carrasco spent one and a half years at the Pulkovo Observatory measuring the circle readings with the Pulkovo automatic measuring machine (C. Anguita).

(c) *KSZ Programme*

At Strasbourg, a meridian catalogue containing 1399 bright K SZ stars, 1026 double stars, and 407 FK4 stars was finished for $+25^{\circ}$ to $+72^{\circ}$. The use of the synthesis method has improved the individual accuracy and the relation to the FK4 (P. Lacroute) – The 'Bucharest K SZ Catalogue, Zone -11° to $+11^{\circ}$ ' was published by Marcus (08.041.007), and a comparison was made with the AGK3 in the zone -5° to $+11^{\circ}$; the results of the comparison will be published. An amelioration of positions of 238 FKSZ stars in the zone -20° to $+24^{\circ}$ observed at Bucharest as reference stars for the K SZ programme (1955 to 1962) was published by Tudor and Toma (06.041.024; 07.041.031) – Five catalogues of K SZ and FKSZ stars compiled at the Odessa Observatory have been published (*Naukova Dumka*, Kiev, 1970, in Russian). At the Sternberg Institute, Moscow, the catalogue of right ascensions of 589 FKSZ stars in the FK4 system has been completed and published by Hommik (07.041.009). The catalogue of right ascensions and declinations of K SZ stars in the zone $+60^{\circ}$ to $+90^{\circ}$ has been published by Meshkova and Osborneva (07.041.012) (A. A. Nemiro) – For inclusion of stars down to 9th magnitude, especially FKSZ stars, into the fundamental system, right ascensions and declinations of 651 FKSZ stars in the zone $+40^{\circ}$ to -90° will be observed in the FK4 system with the Repsold meridian circle in Santiago, Chile. Six observations are intended for each star; the programme started in December 1972 will take about two years (C. Anguita).

(d) *PZT and latitude star Programmes*

It has been generally recognized that meridian observations of PZT stars are required for relating the positions of these stars as closely as possible to the system of the FK4 and as an aid for the determination of proper motions. Reversely, the PZT observations can contribute to the improvement of the fundamental system, if the positions of the PZT stars are known in the system of FK4. For meridian observations Yasuda and Kamijo (06.041.026) have compiled a list of 1717 Northern PZT stars including the stars of eight PZT catalogues in current use and the PZT stars in new lists of three observatories. It also contains 60 ILS stars and the stars selected by Takasi (07.041.016) for PZT observations on the parallel of 39° N. Twelve meridian circles and one vertical circle are expected to participate in the observation of the stars in the list; four to six observations will be made per star with each instrument. From a comparison of the positions in the eight PZT catalogues in current use with those in AGK3R, Yasuda (06.041.027) has shown that the dispersion in the PZT catalogue positions is large and that the coefficients of period terms are significant. Yasuda and Aoki (07.045.003) have shown that the discrepancy between the annual components of the polar motion derived from latitude and PZT observations is entirely due to positional errors in the PZT catalogues. Some observatories have reported on their participation in meridian

observations of the Northern PZT star list: At Tokyo the observations have continuously been carried out since the middle of 1971. At Bucharest an observing programme began in October 1971 (zone $+41^\circ$ to $+63^\circ$) which contains, besides Yasuda's list, 200 PZT stars for the PZT at Prague ($\delta + 50^\circ$) and double stars from Scott's list, zone $+40^\circ$ to $+65^\circ$. Before the observations started the Bucharest meridian circle was investigated by observing 31 series of FK4 stars in the zenith zone in declination. Ionescu and Tudor (07.032.027) have reported that no zenith discontinuity was found. At Besançon, mainly the stars in the zone $+20^\circ$ to $+40^\circ$ of Yasuda's list have been observed. At Herstmonceux the observations have started at the beginning of 1972. At Uccle, observations of PZT and latitude stars are being made with the great Askania meridian circle; at San Fernando, Cádiz, the observations will commence in 1973.

At the Belgrade Astronomical Observatory a differential catalogue of declinations of 3957 latitude stars (in the FK4 system) was compiled by S. Sadžakov and D. Šaletić. The manuscript is in the preparation for print. The catalogue is based on observations made with the Askania meridian circle 190/2578 mm, and it includes stars from the list of the Moscow Sternberg Institute. All stars were observed at least four times. The mean square error of one observation is ± 0.36 and of one catalogue position it is ± 0.19 . The Pulkovo Observatory has assisted in the final investigations. Intended are observations of PZT stars, planets and Sun with the same meridian circle (B. Ševarlić) – At the Engelhardt Observatory, Kazan, meridian circle observations of 2800 latitude stars have been completed. Preliminary values of declinations have been derived. The catalogue of declinations of 192 stars from the Moscow programme of wide pairs, deduced from observations with the meridian circle of the Odessa Observatory, was published (*Naukova Dumka*, Kiev, 1970; in Russian). At the Sternberg Institute, Moscow, the compilation of the general catalogue of latitude and PZT stars is being continued (A. A. Nemiro) – Proverbio has compared the ILS catalogue by Melchior and Dejaiffe with the GC and has made an analysis of the proper motion errors (paper in press).

(e) *Zodiacal stars*

The Herstmonceux observing programme contains 3087 lunar-occultation stars of Robertson's zodiacal catalogue (APAE X part II) to be observed four times each, and this project was 45% completed by January 1972 when Yasuda's PZT stars were added. At the U.S. Naval Observatory the six-inch transit circle is expected to commence observations on the zodiacal star programme in late 1972. A selected number of Yasuda's PZT stars will also be included in this programme.

(f) *Photographic positions*

(f. 1) *AGK3*

The Hamburg Observatory has distributed copies of the catalogue to the Astronomisches Rechen-Institut, Herstmonceux, Pulkovo and Washington on magnetic tape on which stars with excessive discrepancies between positions from neighbouring plates were omitted. Meanwhile, these positions have been remeasured, and revised values have been incorporated on the master-tape in Hamburg. Remaining large residuals are being checked. In the final catalogue, nevertheless, some stars will be missing on account of unexplained discrepancies. Some comparisons with modern catalogues were made, some more comparisons are in preparation. The project of printing the AGK3 has been under consideration; the whole catalogue could be printed in one volume of about 900 pages (200 star positions and proper motions on one page) including information for regaining the AGK2 in a revised edition, together with BD-numbers, spectral types, and magnitudes, the latter taken from AGK2. For the region north of $+40^\circ$, the AGK3, AGK2 (revised) and the Astrographic Catalogue (Zones Helsingfors, Catania, Rome-Vatican, Greenwich) were combined to a general catalogue of positions and proper motions on the basis of work done by Günther and Kox. At present, the catalogue exists on punched cards but is not yet usable due to numerous discrepancies in the basic data; a remaking of the catalogue is under consideration.

The untimely death of H. Kox (June 1971) interrupted his endeavours which aimed at removing the large discrepancies found in the process of computing (W. Dieckvoss).

(f. 2) *Optical counterparts of radio sources*

At Herstmonceux the programme for measurement of absolute positions of optical counterparts of radio sources has been continued. Observations on the Isaac Newton Telescope and the 26 in. refractor for nearly half of the current list of 48 sources are complete (C. A. Murray).

(f. 3) *Southern sky*

Photographic observations of the whole southern hemisphere with the Cape astrometric camera have now been completed (about 6000 plates). All the plates will be measured at Herstmonceux on the GALAXY machine which has been installed recently. Preparation of search coordinates of SAO stars, and sufficient fainter stars to provide strong overlap solutions, is under way. Clube (06.041.053) has published a review of methods used in producing photographic star positions in earlier Cape catalogues (C. A. Murray) – The Sydney Observatory has been going on with the photography of zones of the southern sky. The plates cover an area rather more than 5° square, and the centre of each plate is included in the area of its neighbours to provide for overlapping reductions. The plates centred on zones from $-43^\circ 30'$ to $-63^\circ 30'$ are all complete; at present work on the zones -41° and -66° is going on (H. Wood) – At the U.S.A. TOPOCOM a team headed by W. D. Googe, C. F. Lukac and H. Eichhorn as consultant finished the new reduction of the measurements in the Cape Photographic Catalogue 1950 zones -52° to -56° and -56° to -60° , as well as the establishment of a catalogue from new measurements of plates that had been taken at the Sydney Observatory in the zone from -48° to -54° . The reductions were carried out by a plate overlap method described by Googe *et al.* (04.031.002). The rms error of a position in the new reduction is $0''.15$ as compared to $0''.18$ in the original reduction in the 52° to 56° Cape zone and to $0''.10$ from originally $0''.15$ in the -56° to -60° zone. The new catalogue based on the Sydney plates contains the stars complete to about 9th magnitude and in addition to it two faint stars per square degree from the Astrographic Catalogue in implementation of a suggestion by Eichhorn for establishing the positions of faint stars free of magnitude equation for the purpose of eventually calculating improved reduction parameters for the Astrographic Catalogue (H. K. Eichhorn-von Wurmb).

V. SPECIAL PROGRAMMES

(a) *Observations of stars*

The W_{50} Catalogue will include several special programmes observed on the six-inch transit between 1963 and 1971. These are (a) the Bright Star Programme, (b) a special group of 232 carbon stars, and (c) 155 Radio Source reference stars (B. L. Klock) – At Tokyo the reductions of the BS observations between -10° and -30° have been completed. The observations of O and B stars north of -25° and brighter than visual magnitude 8.5 are being continued together with those of Northern PZT stars. The observing list contains the stars in the three lists compiled by Blaauw, Parenago, and Rubin (H. Yasuda) – At the Odessa Observatory meridian observations of eclipsing binaries and red irregular variable stars are being continued or finished (*Naukova Dumka*, Kiev, 1970) (A. A. Nemiro) – Bright stars and double stars are also contained in the catalogue completed at Strasbourg (see section IVc). Cape has completed 63% of the BS Programme with no estimate as to the completion of the programme. Bucharest has completed the BS observations, and the reductions are 98.2% finished. At Herstmonceux observations of selected variable stars continue.

At the Copenhagen University Observatory, Brorfelde, a catalogue for α and δ in the FK4 system of 2246 stars brighter than visual magnitude 11.0 and in the declination interval -10° to $+80^\circ$ was completed. It is based upon observations made with the meridian circle from September 1967 to December 1970. The catalogue is available in machine readable form; it will be published soon. Most stars were observed four times, and the mean errors of a single observation in right

ascension and declination are $\pm 0^{\circ}0152 \pm 0^{\circ}0001$, $\pm 0^{\circ}213 \pm 0^{\circ}002$. The catalogue is a continuation of the observations from 1964 to 1967 published by Laustsen (*Publ. Københavns Obs.* No. 197, 1968) containing FK4 Sup stars, OB stars, stars nearer than 20 pc, high velocity stars, brighter B8–B9 type stars, and selected stars from the Hyades. Since December 1970 observations have been continued with the main weight on the PZT star programme; 2/3 of these observations were completed in September 1972. In 1971 some of the plates from the automatical photographic micrometer have been measured on the GALAXY in Edinburgh, and recently a new Leitz measuring machine has been taken into use. In the near future the Photoelectric Recording of the Circle will be connected with a mini-computer to give an easier and more reliable reduction (H. J. F. Olsen).

(b) *Observations of planets*

On the initiative of S. Débarbat a collaboration of several observatories has been established for the observation of planets with Danjon's Astrolabe. Observations which are already available for Jupiter are those made at Quito by Davilá (07.041.040), and by Davilá *et al.* (07.041.041), at Besançon by Bénévidès *et al.* (05.041.041), and at Paris by Bartholot *et al.* (05.099.003). Débarbat and Grudler have carried out an analysis for these observations which is in press. The results of observations made at Quito in 1969 are in preparation. Observations of Saturn were made at Quito by Alvaro *et al.* (07.041.043); they were followed by others made at San Fernando, Alger, Besançon, and Paris which are in the state of reduction. Observations of Uranus were made at Sao Paulo by Débarbat *et al.* (02.101.003); a rediscussion of observations carried out at Alger was made by Pham Van (05.101.001; 05.101.016). Observations of Mars, Jupiter, Uranus were made at Sao Paulo in 1969 and published by Bénévidès *et al.* (05.041.033). Observations of the minor planet Vesta made at Alger in 1969/70 are in press. From the experience with the observations so far completed S. Débarbat concludes that the accuracy of the observations of planets with the astrolabes is equal to that of the stars and at least equal to that of observations made with meridian circles and astrographs (S. Débarbat).

VI. MISCELLANEA

(a) *Study group on astronomical refraction*

The members of the Study Group are G. Teleki (Chairman), W. Altenhoff, B. Garfinkel, E. Høg, J. A. Hughes, C. Kakuta, I. G. Kolchinskij, I. I. Mueller, A. I. Nefed'eva, C. Sugawa, H. Yasuda. The task of this Group will be to prepare a report on the present state and the future of the astronomical refraction investigations for presentation at IAU Symposium No. 61 in Perth 1973. Teleki (06.082.081) has emphasized the desirability of an international agreement on astronomical refraction. The almost universally used Pulkovo tables should be revised for every observatory to meet its local circumstances. Teleki (02.082.079) has completed an investigation on the local variation of astronomical refraction, and jointly with Sévarlić (08.082.44), has described a method for determining anomalous refraction from astrometrical measurements in the zenith zone. Teleki (08.045.023) has proposed the inclusion in the observational programme of latitude services a number of Talcott pairs with greater zenith distances, and a paper on the determination of anomalous refraction influences from astrometric data is in press. The problems of refraction have also been discussed at the Golosseyevo and Engelhardt Observatories (*Trudy 18th Astrometr. Conf. U.S.S.R.*, p. 250, 1972).

(b) *Other activities*

Billaud (07.112.014) has made a tentative determination of proper motions from Paris astrolable observations over a period of 15 years – At the U.S. Naval Observatory proper motions for the W3₅₀ Catalogue are nearing the stage of completion and should be published in 1973; a determination of more definitive proper motions for the stars of Blaauw's list is in an advanced stage of completion – R. H. Tucker has reported that at Herstmonceux preparations continue for arranging proper-motion data to be manipulated by the computer. All the GC and Gyllenberg (Lund) tables of systematic corrections ('GC minus Catalogue') have been assembled on magnetic tape. Progress has

been made in the extraction of data from the literature for calculation of proper motions of the Blaauw list of O and B stars, and the zodiacal stars in the current observing programme – At the Tashkent Observatory the observations of right ascensions of Polaris made with the meridian circle from 1946 to 1952 were analysed by Bykov (05.041.038). Division errors of the meridian circle of this observatory were investigated using a modification of Bruns' method (*Circ. Tashkent Astron. Inst.* No. 36 (383) and 38 (385)) – At the Pulkovo Observatory a method has been compiled for absolute determination of declinations of equatorial stars by means of micrometric measurements only (*Trudy 18th Astrometr. Conf.* p. 133–141, 1972) (A. A. Nemiro) – The re-reduction of the Cookson Zenith Telescope observations has led Atkinson (08.041.004) to program the post-1960 aberration so that it can be used for any date without input from the Ephemeris and without the need for interpolating between 0^h values. The method has proved accurate enough to reveal small systematic errors which have so far been left in the Astronomical Ephemeris. He has now also re-programmed the nutation to include the pole-of-figure terms, since in that case the so-called 'dynamical variation of latitude' disappears, together with a similar oscillation in time. – On the basis of Resolution No. 5 adopted by IAU Com. 8 at Brighton, P. Bacchus and A. Hecquet have studied a possible space programme of astrometric observations for the establishment of a homogeneous reference system and for stellar parallaxes – Eichhorn *et al.* (03.041.003) published a catalogue of 502 very accurate positions in the region of the Pleiades. Eichhorn has finished work on a book entitled *Astronomy of Star Positions – A Critical Study of Star Catalogues* to be published by Frederick Ungar Publ. Comp. in 1973 – Proverbio (07.045.033) has determined corrections in declinations for 73 GC stars from latitude observations carried out from 1961 to 1969. López Palacios (06.158.124) has published a catalogue with coordinates of nebulae, reference stars and control stars measured on 144 plates taken with the Carte du Ciel Astrograph at San Fernando, Cádiz; the plates covered 48 areas of the Pulkovo Programme in the zone -5° to -25° – H. Wood reports that at Sydney a programme towards finding a suitable site for the Observatory to carry on its observational work has been continued, and a selection of places has been made which will be subjected to more critical examination and testing. It will certainly be possible to find an inland place which for clarity of the atmosphere, favourable meteorological conditions and sky darkness is much better than the present site or any situated in the coastal areas – At Leiden, a study of the observational history of stars has been made by G. van Herk as an aid in setting up observing programmes. Stars with ten or more entries in the GFH were listed. The number of references in the Index I (Hamburg) with observations from 1900 to 1925 and in Index II (1925 to 1960) are given, as well as other details. Stars were selected from the Hamburg Index when more than four references are available. The list covering the northern sky has been completed and will be made available on request; the southern sky list will be completed in 1973. From a comparison of positions in recently published meridian circle catalogues G. van Herk has found that modern observations in right ascension are still affected by magnitude equations and that rather large differences exist between some catalogues with respect to the α - and δ -dependent terms.

VII. PRIORITIES AND RESOLUTIONS

The IAU General Secretary has requested a short mention of priorities and expected developments for discussion at a meeting of the Commission in Sydney. A list of priorities may differ from a list of resolutions in the usual sense, since the first list shall be set up for the advice of a recently formed 'Panel on Scientific Priorities' in the International Council of Scientific Unions, while resolutions adopted by the Commission have often been of importance only for the workers in the field of positional astronomy. I suggest the following list of Priorities for consideration and endorsement by the Commission at the XV General Assembly:

(1) The continuation of observations of positions of stars and members of the solar system with transit circles, meridian instruments, and astrolabes is of vital importance for progress in astronomical research, space research, geodesy, and geophysics.

(2) Observations relevant to (a) the improvement of the fundamental system of positions and proper motions, (b) the establishment of a reference system to the faintest possible magnitude limit,

and (c) the derivation of proper motions of special objects are of immediate importance. All investigations that contribute to these goals have to be encouraged.

(3) Development of new instrumentation and techniques have to be encouraged which endeavor to improve the measurement of positions of stars and of members of the solar system.

Furthermore, I have to report that IAU Colloquium No. 20 on 'Meridian Astronomy' held in Copenhagen 1972 September 25–28 has submitted the following Resolutions to be considered and endorsed by the Commission 8 at the XV General Assembly:

(1) The recommendation made by Commission 8 at the XIV General Assembly concerning the development of new instrumentation and techniques is re-affirmed. In particular, the provision of a modern transit circle for the Tokyo Astronomical Observatory is strongly recommended. It is further recommended that a Study Group be established for horizontal meridian circles.

(2) It is recommended that an improvement of the FK4 and its extension to a fainter magnitude limit, resulting in a new fundamental catalogue, the FK5, be carried out at the Astronomisches Rechen-Institut, Heidelberg; that observatories throughout the world contribute to this project by providing basic observations, on punched cards if possible; and that all information pertinent to the formation of the FK5 be transmitted to the Astronomisches Rechen-Institut with the observations.

(3) It is recommended that meridian catalogues should include, in addition to the tabular magnitude on a recognised system, an indication of the screen or screens used for each star, so that the approximate magnitude at which the star appeared to the observer can be deduced.

(4) It is recommended that programmes of observations of fundamental stars, with meridian circles and astrolabes, should include members of the solar system.

(5) It is recommended that the SRS catalogue should be compiled by the U.S. Naval Observatory, Washington; and that this observatory should send the basic data to the Pulkovo Observatory and, on request, to other institutions.

(6) The recommendation made by Commission 8 at the XIV General Assembly concerning the inclusion of FKSZ stars in fundamental observational programmes is re-affirmed, with particular reference to observatories in the southern hemisphere.

(7) It is recommended that the work of the Study Group on Astronomical Refraction that has been formed by Commission 8, should continue to be supported.

W. FRICKE

President of the Commission