4. ON THE ORGANIZATION OF MERIDIAN OBSERVATIONS OF THE CATALOGUE OF FAINT STARS

By E. Rybka

1. *General remarks.* In the report of Prof. Zverev the most important problems of the catalogue of faint stars have been exposed. I restrict my remarks to the organizational topics of meridian observations in connexion with the catalogue and to instrumental difficulties which arise in such a work.

There are three essential problems which are to be solved by meridian observations:

(1) The absolute determination of co-ordinates of 931 fundamental stars;

(2) The differential observations of the general catalogue of about 20,000 stars;

(3) The comparison of the new fundamental system with the FK 3 system.

The catalogue of faint stars will have its full value if it contains the stars of the northern and southern hemispheres with equal weights. The organization of new meridian observations on both hemispheres is therefore indispensable. It would be necessary to organize the international co-operation of observatories for that purpose. It would be therefore very important to establish the list of observatories, which will consent to participate in the collective meridian observations for the catalogue of faint stars, to determine the scope of the work in the particular observatories and to elaborate the methods which will secure homogeneous results.

The existing fundamental systems, though nearly homogeneous, contain several stars whose positions still need considerable corrections. For example, it results from the observations made during the past 20 years that even the co-ordinates and proper motions of some stars of FK 3 need to be corrected. Especially the right ascensions of the stars in FK 3 near the north pole differ systematically from those in the lower declination zones. It would be reasonable therefore to include in the observational programme of the new fundamental catalogue the stars of FK 3 near the north pole for the sake of increasing the accuracy of their positions, which are needed in the time-service and in geodesy.

The observations for such a catalogue cannot be restricted to observatories of one country but they need extension to many countries in the northern and southern hemispheres of the Earth. Only then can the comparison of simultaneous observations made in different latitudes under different local conditions give the necessary data for determining the character of the systematic errors of the instruments participating in this work.

At present the meridian observations for the catalogue of faint stars are carried on in eight observatories of the U.S.S.R. and in one observatory in Poland (Wrocław). The extension of the work to further points of the northern hemisphere is quite easy because most of the meridian instruments are situated in this hemisphere. But the number of suitable meridian instruments in the southern hemisphere is less than ten and the organization of simultaneous absolute determinations of positions of stars encounters very serious difficulties. Perhaps it would be advisable to transfer some of the meridian circles from the northern hemisphere into the southern.

A question may be raised, whether it would be reasonable at present to organize the meridian observations in many observatories with the aid of instruments which were constructed 30–50 or more years ago while the technical progress in construction of instruments is very rapid. Opinions have been expressed that the number of existing meridian circles on the Earth is excessive(1). L. A. Sukharev in the Pulkovo Observatory(2) and R. d'E. Atkinson in the Greenwich Observatory(3,4) have given very interesting schemes and models of meridian instruments of a new type with horizontal telescopes and moving plane mirrors. Also the endeavours made in Greenwich and Washington observatories to construct new, more perfect meridian circles are watched with the greatest interest by meridian observers(5). We must state, however, that all such very interesting and promising work has not yet reached such a stage of development that the serial production of them may be started and organization of regular observations be possible.

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The meridian observations must therefore still be performed with old instruments, which are, however, to be modernized. Besides the modernization of instruments, the methods of observation need further automatization.

2. *Absolute determination of right ascensions.* It is not possible for me to mention all practical topics, which are very important for meridian observers and which are not yet solved satisfactorily. As all these problems are to be discussed in detail at meetings of Commission 8, I should like to mention only a few of them.

First, I want to lay stress on investigations of pivots and deformations of bearing. Such investigations must necessarily to be executed before the absolute determination of right ascensions is started. Unfortunately such investigations are difficult for instruments with full axis, as the existing methods do not give satisfactory results. We must, according to Blazhko(6), consider the depressions which are formed on bearings of transits. Though the real form of pivots may be known, deformations of bearings if not taken into account may vitiate the results, like additional irregularities of pivots. Further investigations of this kind of instrumental errors seem to be very desirable. Here all deformations of instruments caused by gravity and changes of temperature, especially side-flexure, are to be added.

The second problem concerns the methods of recording the moments of transits. Photo-electric recording is to be regarded at present as the best one. Very important progress has been reached in this direction by N. Pavlov in U.S.S.R. Though the application of photo-multipliers reduces largely the delays of recording, the method still needs further improvements before an application to the absolute observations of faint stars by the aid of large meridian instruments can be made. Old methods of recording therefore are to be perfected. It seems that the application of small synchronous motors solves the problem satisfactorily if they do not disturb the instrument significantly.

The printing chronograph is to be regarded as a great improvement in comparison with the classical writing chronograph. The best method has been given however by Reicz in Lund in 1950(7). The method consists in the photographing of rotating disks synchronized with clocks. The revolution of the rotating disk with the greatest speed has a period of 1 sec. The photographs are taken by using short flashes of light in moments of closing the circuit in the impersonal micrometer. A similar method has been developed in Moscow by Brandt.

The discussion of all mentioned topics in Commission 8 seems to be desirable.

3. *Absolute determination of declinations.* Very important problems are still to be solved in the case of absolute determination of declinations of faint stars. The absolute declination is determined independently from right ascension only when both co-ordinates are determined by different instruments—for example by a transit instrument and by a vertical circle. The systems of right ascensions and of declinations based on simultaneous observations with meridian circles are interdependent. In the absolute determinations of co-ordinates of stars for the catalogue of faint stars the principle has been adopted of determining each co-ordinate separately. In two observatories, in Pulkovo in U.S.S.R. and in Wrocław in Poland, the absolute right ascensions will be determined with the aid of transit instruments and the absolute declinations by the aid of vertical circles.

Such a method of determining right ascensions and declinations of stars separately has been used at Pulkovo since the foundation of the observatory in the nineteenth century It has been demonstrated as very effective, because owing to this method the Pulkovo catalogues are of great accuracy. We should take, however, into consideration the fact that there is a small number of large vertical circles and therefore the main part of absolute determination of declinations must be performed by meridian circles. In this case it is advisable not to make such observations simultaneously with the determination of right ascensions. I should like to remark that the vertical circles are not so stable as the meridian ones and therefore the investigations of instrumental error are more difficult than in the case of meridian circles.

For both types of instruments the problem of refraction still needs further improvements. The refraction, even the mean one, depends on the topography of the surroundings

of the observatory and on properties of the buildings in which the instruments are housed. Each observatory ought to determine its own system of refraction which may be joined with the meridian flexure of instruments as being dependent also on zenith distance. The total effect of refraction and flexure would be a composite function of zenith distance valid for the particular instrument only. In this way the effect of flexure which is not yet known satisfactorily may perhaps be eliminated.

The errors of graduation require very careful investigations. It seems that it would be advisable to replace direct visual measurements by photographic methods. The photographs may be obtained in short time and then measured in the laboratory. More reliable and more accurate results are to be expected in this way. The elaboration, however, of suitable methods for such investigations would be necessary.

Photographic methods have been applied in several observatories for the recording of divisions of graduated circles during observations. Such methods are advisable for the observations of the catalogue of faint stars because considerable gain in time and in accuracy is expected in this way. There is no difficulty in the application of photography to the recording of divisions of graduated circles in the case of meridian circles as they are supported by two piers. It is more difficult to do that in case of vertical circles.

4. *Organizational remarks.* The following conclusions result from the considerations listed above. First, the construction of new instruments would be advisable for a successful execution of the catalogue of faint stars, in any case the modernization of old instruments would be necessary. Secondly, co-operation of observatories in observations and laboratory investigations all over the world is very desirable. The results of such organized work will give good fundamentals of the catalogue of faint stars.

A new fundamental catalogue of faint stars will be of great importance in many divisions of astronomy. It is evident that the realization of the plan worked out in U.S.S.R., i.e. the determination of co-ordinates and proper motion of 20,000 stars, distributed uniformly over the whole sky, needs the participation of observatories from both hemispheres of the Earth. At present the chief work is done in Soviet observatories. Since 1949 the observatory in Wrocław in Poland has joined the observational work. The observations in Wrocław are made by the aid of two 16 cm. Repsold instruments, the transit instrument and vertical circle. The list of stars and the auxiliary tables containing the Bessel constants *a*, *b*, *c*, *d*, etc. with their annual variations have been received from the U.S.S.R.

At present relative observations of positions of 500 stars are executed at Wrocław in the system FK3. We have finished the observations in the one position of both instruments and we expect to finish the observations in the second position in 1953. We intend afterwards to begin the absolute determinations.

As it has been stated above it would be necessary for further development of the work to extend the observational work to observatories in other countries in all parts of the Earth. Such co-operation of observatories will be indispensable for absolute and relative observations. The more instruments that participate in the determination of absolute co-ordinates, the better will be the result. Especially the observations in the observatories of the Southern Hemisphere will be very desirable: at least 6 meridian instruments, in Australia, South Africa and South America.

The differential determination of both co-ordinates may be executed simultaneously by meridian circles. The sky is to be divided suitably into declination zones, partly overlapping, at best to half their extent. In this case each star will be observed in two zones, and if each could be observed in three observatories in two positions, the co-ordinate of each star in the general catalogue will be the mean of 12 determinations. The observations in different observatories should be nearly simultaneous.

5. *Conclusions.* The difficult task of elaborating a homogeneous catalogue of faint stars, especially to get homogeneous observational material with the aid of meridian instruments, will thus require an international co-operation of observatories. A special committee is necessary for the arrangement of work in the observatories. It is very desirable that the Committee should arrange periodic conferences of meridian observers who will

participate in the execution of the catalogue of faint stars. A suitable resolution of Commission 8 and of the General Assembly seems to be necessary for that purpose. It is evident that the success of the whole enterprise largely depends on good organization.

Fundamental astrometry is at present in such a stage of its development that the co-operation of many observatories in different parts of the Earth is urgently needed and is indispensable for further progress of investigations. Such scientific co-operation will facilitate mutual understanding and will contribute in the consolidation of peace in the world.

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5. THE YALE PHOTOGRAPHIC ZONE PROGRAMME

By D. Brouwer

In 1950 the Yale Observatory published in Vol. 22 of its *Transactions* the concluding volume of the photographic repetition of the AG catalogues between declinations $+30°$ and $-30°$. During the past year the supplementary Vol. 23 has also appeared. An important part of the contents of this supplementary volume is the comparison with the *General Catalogue*, both as to position and proper motion, of all the zones within the limits $+30°$ and $-30°$. This is therefore an appropriate time for an evaluation of the programme to date and an indication of its future possibilities. Before taking up this subject I should like to record that the project was initiated by the late Prof. Frank Schlesinger who was the Director of the Yale Observatory from 1920 until 1941. Much of the credit for the work belongs to Dr Ida Barney, who has made one-half of all the measurements and supervised all of the calculations and the preparation of the printer's copy for the various volumes. She has been in full charge of the work since Prof. Schlesinger's retirement.

It should be remembered that the Yale project was begun in 1914 as an experimental project at the Allegheny Observatory with the photography, on plates covering $5° \times 5°$, of a zone centred on the equator. The systematic plan of undertaking the photography of the sky between $+30°$ and $-30°$ was begun with the zone $+20°$ to $+30°$, photographed in 1927–28 and published in 1933–34. The *Albany General Catalogue* appeared in 1936–37. Obviously it was impossible to compare the earlier volumes of the programme at the time of their publication with the GC.

Even for the large plates covering a field of $11° \times 11°$ the GC does not furnish suitable reference stars for reduction of the photographic measurements. The stars are not sufficiently evenly distributed, moreover, the fainter stars in the GC have, generally speaking, the weaker positions if brought up to the epochs of the photographic series. Nevertheless, as is shown in Vol. 23, it is possible after a catalogue has been completed to obtain the systematic differences between the zone catalogue and the GC. Since the difference GC minus FK3 is well known, the corrections of the individual catalogues to the FK3 can also be found. Thus the circumstance that the various zones were originally based on different systems is not a serious drawback at all.

It is unnecessary to give many details concerning the method used for obtaining the proper motions printed in the Yale catalogues. Both the early AG positions (to be abbreviated AGK1) and the photographic positions at a later epoch may be reduced to the GC. The differences in position, divided by the interval, would then give the