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

proper motions in the system of the GC, provided that both positions are free from systematic errors. The visual AGK 1 positions are known to have a magnitude error. This may be taken from the GC, Vol. **1**, but these magnitude corrections, at least for the fainter stars, are of a provisional nature. The plan used in the Yale catalogues is to take, for suitably chosen groupings according to magnitude, averages by hours of right ascension of the proper motions in right ascension and accept as correction to the *crude* proper motions the mean of the hourly means taken with the opposite sign. The adopted proper motions in right ascension then average zero, taken over 24 hours of right ascension. There are objections to this procedure. Yet, the results have been found to be very satisfactory.

So much about the first photographic epoch. Obtaining a second photographic epoch a suitable interval of years after the first photographic epoch opens up several interesting new aspects.

An example was given by Dr Barney in *Yale Transactions*, Vol. **21**, in which she deals with the Nicolajev zone, originally observed for the AG programme about 1884, first photographed in 1914, and again photographed in 1936–37. The positions for both photographic epochs were carefully examined for errors depending on magnitude. For the later series an objective grating was used. The comparison of central images with first-order spectra gives conclusive evidence concerning the presence of a magnitude effect and makes possible its elimination if present. Both the 1914 and the 1937 positions could be referred to the GC, even though they had been reduced in two systems, both different from the GC. Next it was possible to compute the 1884 Nicolajev positions, by extrapolation from the 1914 and 1937 data, in the system of the GC. By comparing with the observed Nicolajev positions, the systematic reduction to the GC for the 1884 catalogue was obtained for four chosen magnitude intervals separately. The AGK 1 Nicolajev positions could then be corrected systematically to the GC. The definitive proper motions of the individual stars were finally obtained as a linear combination of the proper motions obtained by comparing the 1937 positions with both the 1884 and the 1914 positions.

At this point I should refer to the interesting investigation by O. Heckmann, W Dieckvoss and H. Kox (*Sitz. Deutsche Akad. Wiss. Berlin*, No. VII, 1948). They made use of astrographic catalogue positions newly reduced combined with AGK 2 positions to determine the systematic errors in the Berlin B zone, $+20°$ to $+25°$ The method is now being applied to that entire zone.

It is of interest to note that Miss Barney's work on the Nicolajev zone and the work by Heckmann *et al.* on the Berlin B zone revealed magnitude errors in the declinations of AGK 1. The Nicolajev zone was remarkably free from magnitude errors in right ascension.

The Yale catalogues $+20°$ to $+30°$ differ in several respects from the later zones. The positions given are referred to the equinox 1875.0; the declinations are affected by a systematic error depending on the declination, introduced by the reference stars. These two features made these catalogues less convenient to use than the more recent Yale catalogue volumes. A revision of these two catalogue volumes is now being prepared. The Yale photographic positions are first reduced to the system of the almost simultaneous AGK 2 positions. Dr Heckmann and his colleagues are working up the astrographic positions for the purpose described. In this manner, the revised $+20°$ to $+25°$ zone will: (1) be referred to the equator and equinox 1950.0; (2) be on the FK 3 system; (3) have positions for the epoch about 1930 with the combined weight of the Yale and AGK 2 positions, (4) have an improved system of proper motions. I have made clear that this improvement is made possible through the generous co-operation of Prof. Heckmann. We are also indebted to Prof. Arnold Kohlschütter for making available unpublished positions obtained in Bonn.

For the zone $+25°$ to $+30°$ the proper motions will be improved with the aid of the *Greenwich Catalogue* for 1910, approximate epoch 1910, declinations $+24°$ to $+32°$ Approximately three-fourths of all the AG stars in the $+25°$ to $+30°$ zone are contained in this catalogue.

Within the next few years we intend to carry out the repetition of the $+50°$ to $+60°$ zone. Photographic positions on $5° \times 5°$ plates were taken at the Allegheny Observatory shortly after the Nicolajev zone was photographed. In 1948 a series of plates measuring $11° \times 11°$ was taken to cover this zone again. We are planning to have this zone measured as a part of a new Yale programme for which plates covering declinations $+90°$ to $+50°$ have already been taken.

Our principal reason for choosing this part of the sky was the fact that a rich catalogue of stars north of $+50°$ declination was observed at the U.S. Naval Observatory in Washington in the years 1941–48. The programme at Washington is now being extended south of $+50°$ Mr F. P Scott furnished a description of the method of selection of stars, given in the Draft Report for the Sub-commission of Commission 8. I quote:

The United States Naval Observatory is now selecting stars between declinations $+50°$ and $-30°$ according to the following precepts: the stars will range in magnitude from 5·5 to 8·5, with occasional fainter stars. They are spaced uniformly with about seventy-five stars per one hundred square degrees. Double stars with components differing by less than one magnitude in brightness and with separations from 1″ to 10″ are being avoided. An effort is being made to select stars with favourable observational histories. The references being consulted are GC, Zodiacal Catalogue, Anhaltsterne, Cape, Greenwich and Washington catalogues and the AG. The zone from $+35°$ to $+50°$ has been selected and is now being observed with the 6-inch transit circle. The selection will be completed by zones as needed to supply stars for the observing programmes. The selection of the stars north of $+50°$ for the observing programme in 1941–48 was made before all the criteria were formulated but it does meet these requirements quite well.

The Washington observations are fundamentally observed and reduced, and the instrumental system so derived is rigorously compared with FK 3 and GC.

Dr H. R. Morgan, in his report for Commission 8 in advance of the Zürich Meeting, commented on the choice of stars to serve for the reduction of large photographic plates:

It is possible therefore to reduce the plates using positions of the brighter stars taken from regular programmes on standard instruments, without special observations of the reference stars. This is a great saving for meridian observers; and, furthermore, it decidedly improves the results by referring the faint stars directly to standard systems. The Yale plates $-30°$ to $+20°$ are being reduced with the Cape and Greenwich observations of all stars to the 7·5 magnitude with fainter stars in sparse places.

It is important to note, as Dr Morgan stated in his report, that the choice of these brighter reference stars is made possible by the use of a coarse grating in front of the photographic objective with a difference of about 3·5 magnitudes between central image and first-order spectra.

Also from Dr Morgan's report, referring to the reduction of the plates from $+50°$ to $+90°$:

The comparison stars are to be taken from the spaced list of brighter standard stars observed at Washington, where plans are made for covering the sky to $-30°$ with such observations. The Washington observations are to be used also for reducing plates taken at Lick Observatory in a general plan to cover the sky with a series of large plates which with double exposure and the use of gratings will provide means of referring the bright stars to the spiral nebulae.

The rate of progress with the preparation of these future Yale catalogues will be determined by the success of the new photo-electric measuring instrument being developed by Dr W J. Eckert and his associates at the Watson Scientific Computing Laboratory.

It thus appears to us that the plan adopted for the Yale catalogues has merits that encourage us to continue along the lines indicated. With the passage of time and diligence on the part of astronomers the quality of the future catalogues will improve in several

respects. For example, some years ago Dr J. Jackson recommended that the re-observation of stars in the GC, especially many of those not in the PGC, be undertaken as soon as possible in order to strengthen the GC where its improvement is most needed. This programme, together with meridian circle programmes that will provide a more uniform spacing, promises within a relatively short span of years a rich system of the brighter stars to which both meridian circle positions and photographic positions of the fainter stars can be referred with much greater certainty than was possible during the past twenty-five years.

The Yale programme owes much to the contributions made by the observatories that furnished the meridian circle observations for the reduction of the plates. In the past star positions were specially observed at Leiden, at the Lick Observatory and Washington. The recent catalogues have depended particularly on star positions observed at the Cape Observatory and Greenwich. In the immediate future we hope to make good use of the catalogues to be published by the U.S. Naval Observatory in Washington.

I have deliberately limited my remarks to the Yale programme and questions immediately related to it. It differs in various ways from the AG programme, from the U.S.S.R. programme and from the Cape programme. Each of these attacks on our common problem has its own particular merits. Each is distinctly different in general procedure, and the independent results will be important. It seems to me that astronomy is best served if these various projects continue side by side.

Dr Nemiro: The programme of the Yale Observatory on the astrographic catalogue is very important. Only one point can be mentioned—that the catalogues of reference stars which were used are based on different systems.

6. REPORT FROM THE CAPE OBSERVATORY

By R. H. Stoy

A programme of photographic astrometric work on faint stars was initiated at the Cape Observatory by Sir Harold Spencer Jones in 1930. Its aim was to do for the sky south of $-30°$ what the Yale Observatory in America and various observatories in Germany and Russia were doing for the sky north of $-30°$ Though somewhat interrupted by the war, the work has progressed steadily and it is anticipated that the whole project will be finished by 1960.

In the south a fresh selection of stars had to be made since it was not possible merely to reobserve the stars in the AG catalogues as was done by Yale. Most of the stars that have previously been observed with transit circles have been included in this new selection and to them have been added stars chosen from the HD and CPD catalogues to secure, as far as possible, a uniformity of distribution. The great majority of the stars observed have visual magnitudes between $7^{m}{\cdot}0$ and $10^{m}{\cdot}0$ and there are on the average 9·1 of them per square degree.

No special provision was made for the zones between $-40°$ and $-52°$, since this part of the sky is already well covered by the Cape Astrographic Zone Catalogues which give the positions and proper motions of 41,400 stars brighter than $9^{m}{\cdot}5$ CPD—an average of 13·8 stars per square degree.

The necessary photographic observations were and are being made with a three-component Taylor-Taylor-Hobson lens of 13 cm. aperture and 2 m. focal length (giving a scale of 102·3″/mm.). After the plates for the first zone ($-30°$ to $-35°$) had been taken, the lens was stopped down to $f/23$ to improve the definition near the edge of the field. For the first two zones ($-30°$ to $-35°$ and $-35°$ to $-40°$) a field of $5° \times 5°$ was measured on each plate, but for all subsequent zones, this field was reduced to $4° \times 4°$ in an attempt to secure greater accuracy.

Suitable reference stars for reducing the photographs are selected and observed with

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