THE REFURBISHED SIX-INCH TRANSIT CIRCLE

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Abstract

The U.S.Naval Observatory (USNO) six-inch transit circle at Washington underwent extensive refurbishment during the interval between October 1982 and May 1983. Major items refurbished on the instrument included the micrometer, the clamp and slow motion arm, the screen system, and a circle. Support instrumentation refurbished included a new digital motor drive system, a new digital micrometer display system, and new environmental measuring systems. Finally, the telescope was completely repainted and the pavilion was extensively renovated.

I. Introduction

Modern technology plays an important role in the collection of vast amounts of astrometric data. The USNO transit circles, and their unique instrumentation, are key factors in the realization of high quality fundamental catalogs. A contributing factor to the USNO's success is the important emphasis placed on a continuing instrumental development program. At the conclusion of the W6-50 observing program the USNO six-inch transit circle underwent an extensive refurbishment effort. Prior to this work, the last comprehensive refurbishment took place in 1972-1973. The ensuing discussion is presented in three parts. The first section will deal with work directly done on the telescope itself. The second section will deal with the development of new ancillary instrumentation, and the third section will briefly discuss the refurbishment of the pavilion.

II. The Telescope

The six-inch transit circle, illustrated in Fig.1, has undergone numerous refurbishments as the electronics technology has evolved since its original construction in 1896. One of the more important items rebuilt in the

H. K. Eichhorn and R. J. Leacock (eds.), Astrometric Techniques, 507–515.

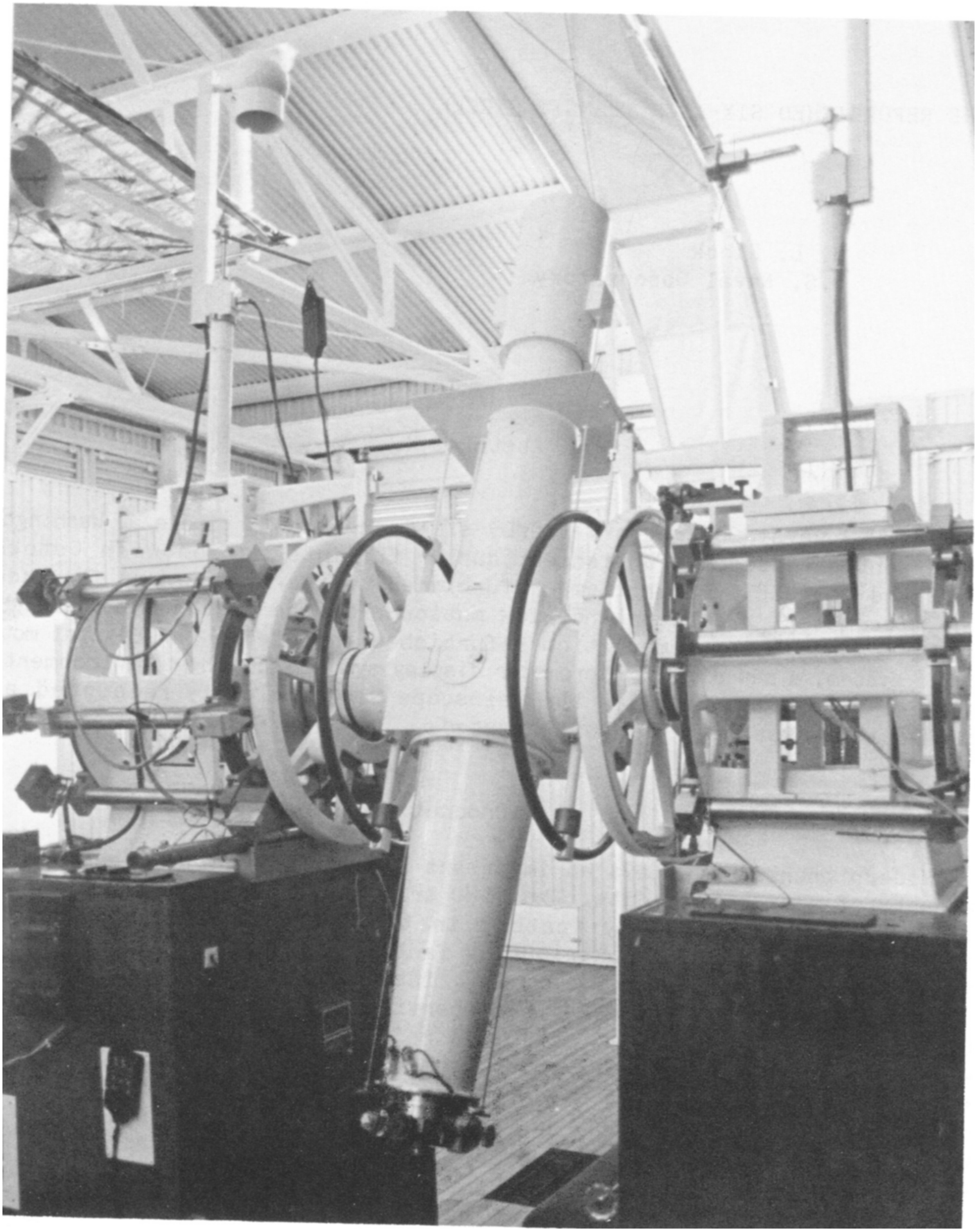

Figure 1. The Six-inch Transit Circle

recent refurbishment was the micrometer. The last major work done on the micrometer prior to this effort was in 1960 when a new motor drive and digitizing system was implemented by Adams(1962). In the most recent effort the micrometer(Fig.2) was extensively rebuilt with a new gear train, a new motor-gearhead combination, a new control transformer, and a new right ascension screw. Additionally, new precision resolvers were installed on both micrometer screws. All of the work was accomplished in the Observatory Instrument Shop under the supervision of J.Pohlman.

Another area of concern for serious transit circle work is that of the magnitude equation. The brighter stars are often not screened sufficiently to enable a proper comparison with the fainter ones. Up to this time all of the fundamental observations with the six-inch transit circle had been made with two screens available for reducing the brighter stars in magnitude. It was decided that it would be highly desirable to have a greater range of screening available and consequently a new screening system was implemented. The new system incorporates four screens which can be inserted into the optical path in any combination. A 0th magnitude star can now easily be screened down to 7th or 8th magnitude.

Any mechanical linkage which connects the telescope proper to the outside world must be carefully scrutinized to avoid any disturbance to the instrument in azimuth, level, or collimation. For several programs the slow motion motor, which applied the tangential motion in declination to the clamp arm, was connected to the cage through a mechanical universal rod linkage combination. This linkage was eliminated with the mounting of the motor directly onto the clamp arm(Fig.3).

A new Heidenhain glass circle was added to the wheel B of the instrument to complement the existing seven-year old Heidenhain glass circle. This new circle was manufactured from the same master as the original Heidenhain circle and it exhibits similar division error characteristics. The circle has 7200 divisions, 20 microns in width, which vary in length from 450 microns to 800 microns. The circle scanning system in use is the same one installed some thirteen years ago. A modification to this system, which will primarily consist of updated ele is expected to be implemented in 1984.

Finally, the telescope was stripped and repainted in the Observatory Paint Shop by A. Pullman. The paint used was a type called IMRON which was selected for its durability under adverse climatic conditions.

III. Ancillary Instrumentation

One of the principal objectives in fundamental astrometry is the measurement of star, sun, moon, and planet positions with the highest possible accuracy. A smooth micrometer drive system, which operates efficiently and with high precision at all declinations, even very near to the pole, enables the observer to concentrate all of his attention on fine guiding efforts. The uniqueness of the digital recording requirements and the scarcity of transit circle customers, have naturally led commercial manufacturers to shy away from the development of new instrumentation in this area. Additionally, most of the commercial systems that were developed and adopted by the USNO have not had the desired reliability. Consequently,

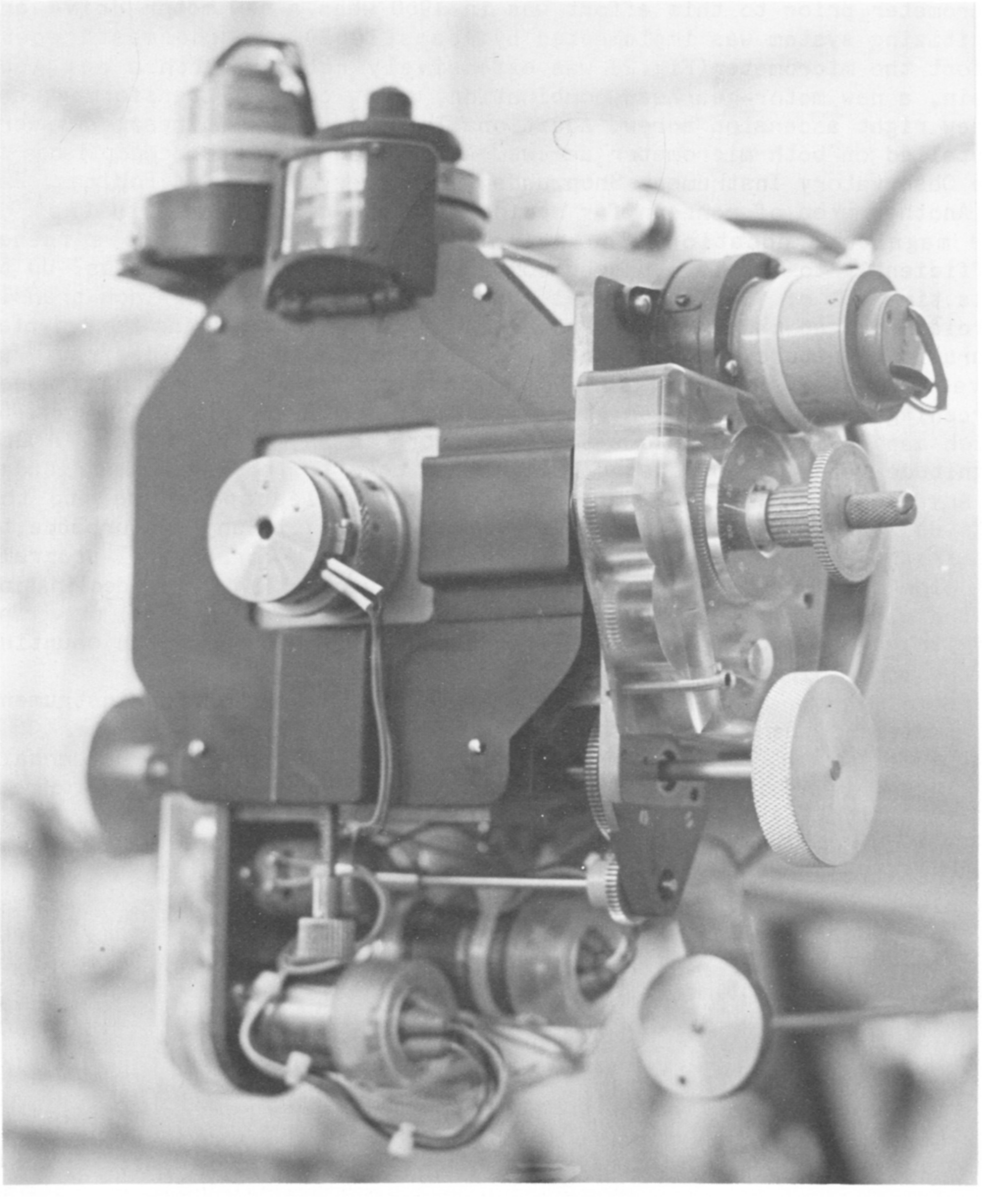

Figure 2. The Refurbished Micrometer

https://doi.org/10.1017/S007418090007697X Published online by Cambridge University Press

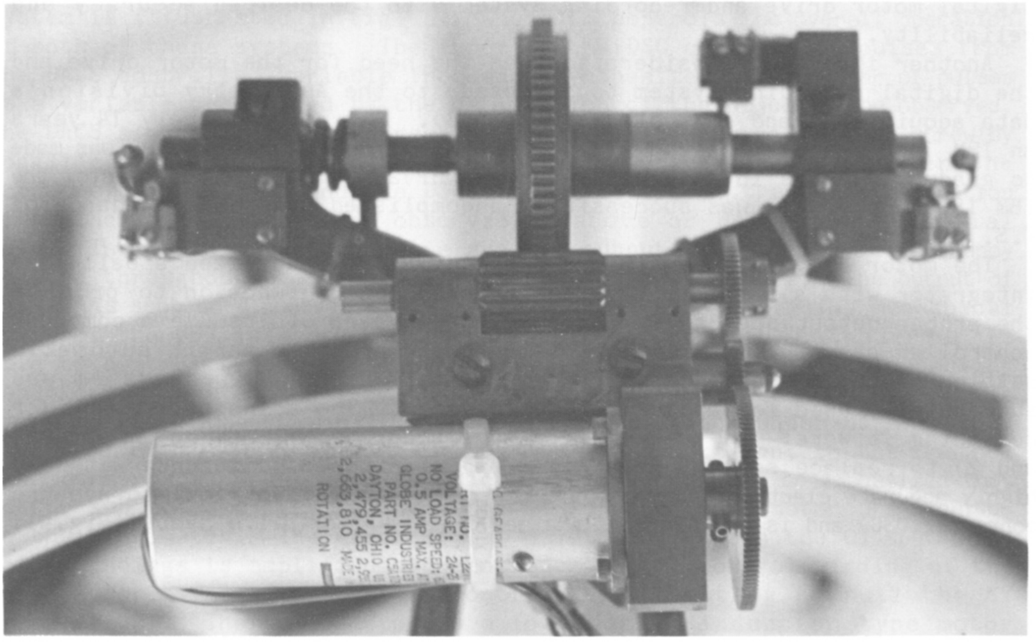

Figure 3. The Slow Motion Motor

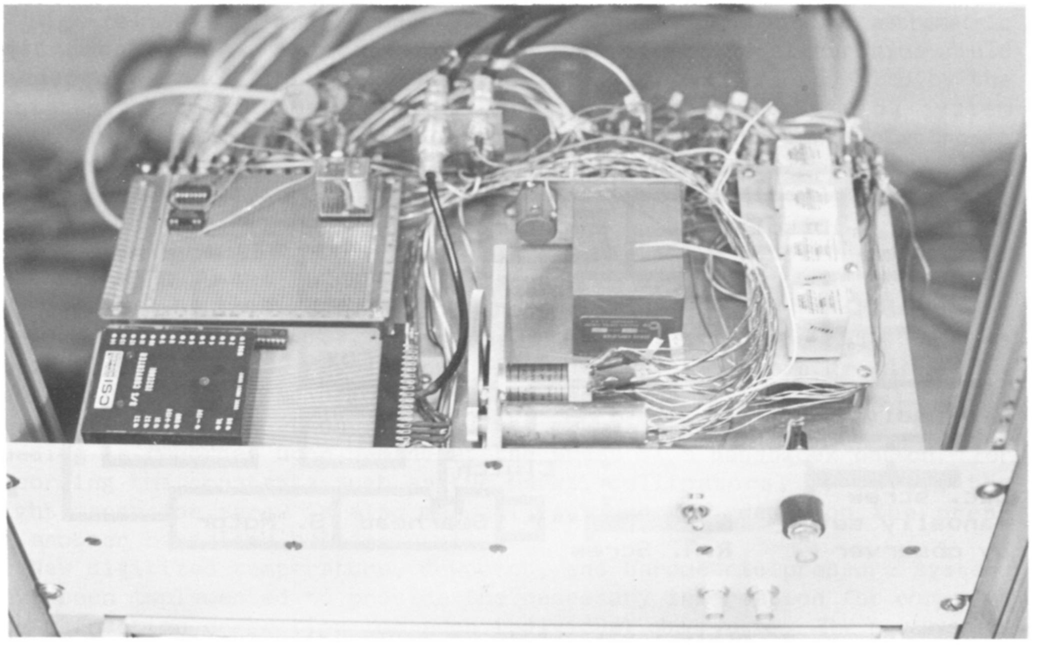

Figure 4. The Digital Motor Drive

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in 1980 an effort was initiated to design and fabricate an in-house digital motor drive and recording system with the desired accuracy and reliability.

Another important consideration was the need for the motor drive and the digital recording system to interface to the Astrometry Division's data acquisition and control systems(DACS). For approximately 14 years an IBM 1800 was used as the six-inch DACS. In 1980 the decision was made to gradually phase in an Hewlett-Packard(HP)21MXE DACS while phasing the IBM 1800 out. This was successfully accomplished under the guidance of F.S. Gauss in 1983.

The motor drive system discussed by Adams(1962) utilized a ball-disc integrator with a mechanically incorporated cosine function to produce the proper output speed. During the latter years of its use a computer controlled stepping motor was implemented in order to permit automatic setting of the right ascension screw speed. This modified system was successfully used for approximately 20 years. The principal reasons for replacing it were: 1) to achieve a more accurate and smoother drive, and 2) to replace several mechanical and electronic components with one highly accurate electronic component. This component is a digital-to-synchro converter(DSC) and is the heart of the new digital motor drive system(Fig.4).

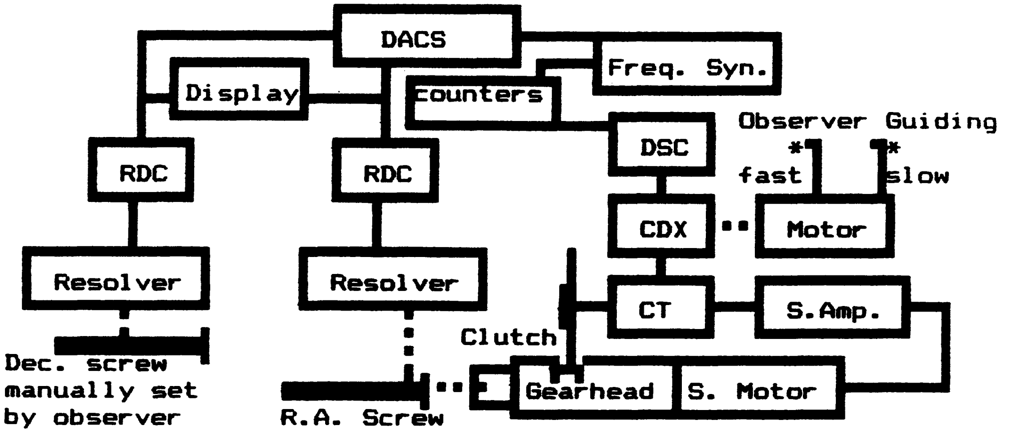

Figure 5. Digital Motor Drive and Recording System

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A block diagram of the digital motor drive and the digital recording system is illustrated in Fig. 5. The DACS controls the overall operation of both of these systems. The input to the DSC consists of pulses from the DACS controlled variable frequency synthesizer. The number of pulses is a variable determined by the declination of the object to be observed. The DACS also selects the direction of travel of the micrometer screw by toggling a bit on the counter chips which provide a buffer between the frequency synthesizer and the DSC. The direction of travel is a function of whether the object being observed is above or below the celestial pole. The DSC produces a 3-wire synchro output. The reference frequency adopted throughout the closed loop servo system is 400hz. The output of the DSC is sent to a control differential transmitter (CDX). The mechanical shaft of the CDX is geared to a reversible DC motor. The observer is able to control the DC motor by pressing guide buttons on his observing handblock. This enables him to differentially speed up or slow down his traveling right ascension wires while tracking the object under observation. The 3- wire synchro output from the CDX is next sent to the control transformer (CT) mounted on the micrometer. It should be emphasized that in the subject servo system only the CT and the servo motor are mounted on the micrometer. The error signal developed between the CT stator and rotor windings is amplified and sent back to the control winding of the servo motor. The motor thus is continually attempting to null the CT error signal. The servo motor is a low inertia induction type motor (size 11) which develops more power than a synchronous motor of the same size. It also has a very fast response time. An electromagnetic clutch completes the mechanical coupling between the servo motor gearhead, the CT, and the micrometer right ascension geartrain.

High reliability is an essential ingredient in any kind of astrometric instrumentation. Modern technology has aided the electronics field tremendously not only through greater reliability, but also by the miniaturization of components. The first commercial digitizing system installed on the six-inch transit circle in 1960 filled two large electronic equipment racks. The new digital recording system developed at the USNO is completely contained in two small electronic chassis only seven inches high.

The heart of the new recording system is the resolver-to-digital converter (RDC). The RDC selected is capable of converting 14 bits of angular information received from the precision synchro resolvers geared one-to- one to the micrometer measuring screws. The resolution is approximately 0.00012 revolutions of the screw. Software developed by Gauss permits the reading of the right ascension screw at equal intervals of time. The declination screw is set manually by the observer and the reading is recorded upon demand at the press of a handblock button. For recording the constants such as the marks, collimators, or level, the right ascension screw is also manually set and recorded upon the press of another handblock button.

New digitized temperature, dewpoint, and barometric pressure systems have been implemented to provide the necessary information for computing the refraction correction for each individual observation. The new systems received extensive calibration checks by J. Hershey prior to their installation. Hershey was also instrumental in the design of a new

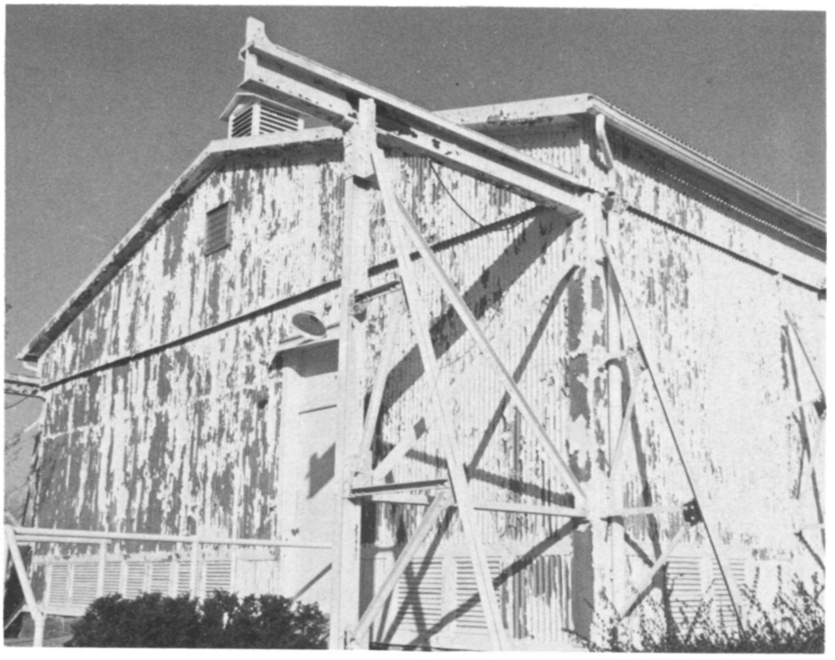

Figure 6. The Pavilion Before Refurbishment

Figure 7. The Pavilion After Refurbishment

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automatic reversing eyepiece for the micrometer. This device will permit the observer to reverse the eyepiece with minimum disturbance to the instrument.

The observer has been provided with a computer terminal to communicate his observing information to the DACS. By this means the observer is able to monitor the status of the instrumental constants as well as other instrumental parameters. The observer also has at his disposal a series of displays that give him the time of transit, the magnitude, and the declination field position for each object to be observed.

IV. The Pavilion

Over the years one of the most troublesome problems with the pavilion housing the instrument has been that of keeping paint on it. Typically a new coat of paint would last 2 or 3 years before beginning to peel badly(Fig.6). The solution to the problem has been to cover the building framework with an enamelized steel skin(Fig.7). Additionally, the east, south, and west sides of the building have a double layer of the material with a series of louvers at the top and bottom. These louvers provide a natural ventilation in the walls thus minimizing the daytime refraction effects. It is anticipated that the new enamelized steel skin will last for twenty years.

V. Acknowledgements

The author would like to express his appreciation to T.J. Rafferty for his valuable assistance during the refurbishment of the six-inch transit circle. He is also grateful to J.R. Hobart, P.A. Heermans, and C.C. Carpenter for assisting with the construction of the new electronic systems.

Reference

1. Adams,A.N.(1962), Sitzungberichte der Heidelberger Akademie der Wissenschaften Jahrgang, 2 Abhandlung, S.56

Discussion:

TELEKI: I should like to suggest to you, and all other observers, to investigate the chromatic characteristics of your instruments in order to calculate the chromatic refraction influences. Practically all position catalogues need chromatic corrections. The IAU Commission 8 Working Group on Astronomical Refraction will therefore suggest the accurate investigation of chromatic characteristics of the atmosphere, the instruments etc. and the correct calculation of the chromatic refraction on the whole.

KLOCK: I will pass your suggestion on to Dr. Clayton Smith, who is the Chief of the Cataloguing Branch.