The fireball was also observed visually by several people, including Morné du Toit, Leez Hoevelmann, Katja Viëtor, Werner Haita and Mattanja van der Vis who were at Fish River Canyon Lodge. They saw the fireball moving to the north in direction of Keetmanshoop and described it 'as orange like fire'. An image provided from Google Earth shows the fireball moved descending left to right and low above the horizon from azimuth 240° to 290°. The direction is consistent with the calibrated videos and the fireball terminated about 70km west of Keetmanshoop. AMS Fireball Report 7488-2021.

Photographic plate measuring machines at the SAAO

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Abstract

For almost 100 years the photographic plate was the detector of choice for astronomical measurements, beginning *ca* 1880 when the technique became sensitive enough to record star images. This era however came to an end in the 21st century when electronic detectors supplanted plates thanks to their higher quantum efficiency and precision.

In this paper I describe briefly some of the photographic era instruments used at the Cape Observatory. Some of them are still extant but others, especially the big ones, have been scrapped in the interest of saving space. Very often these instruments were interesting precision devices and state-of-the-art at the time.

Introduction

Compared to eye measurements, photography achieved great success since it made observations impersonal and more reliable. Photographic imaging enabled many stars to be recorded at once. It yielded a permanent record that could be re-examined, for example to discover and investigate the history of variable and moving objects.

Nearly all astronomical photography was done with glass plates which offered greater stability than typical film materials. Many observatories built up large collections of plates and in some cases they have been digitized, though the longevity of digital media often does not match that of the original photographic materials, requiring re-recording every few years!

Photography was applied in two main areas:

- "Direct" imaging and cataloguing of the sky, yielding positions and magnitudes of the stars.
- The recording of the spectra of stars using spectrographs.

Photography brought with it many changes in technology at the Royal Observatory. This paper concentrates on one of them, namely the devices used to measure the images for extracting numerical data, whether to obtain star positions and magnitudes or to record the wavelengths and strengths of spectral lines.

To make the measurements, many special machines were devised. At first, plates were examined by eye with the aid of travelling microscopes and the results were written down in ledgers. As time went on the equipment became more sophisticated. Scales could be read electronically using optical encoders, photographic densities could be determined using photocells and image sizes could be measured impersonally. Later still, whole plates could be digitized with high resolution and the data recorded on computer-compatible media for extraction of the desired information using digital computers.

Position measurement

The Kapteyn "parallactic" plate measuring apparatus.

This instrument is not in fact one that was used at the Cape but is included because of its indirect connection and historical importance to us!

The need for a large-scale plate measurement programme came with *the Cape Photographic Durchmusterung* initiated by David Gill. The total number of stars in the CPD catalogue was 454875! They were measured under the care of his co-investigator Jacobus Kapteyn of Groningen, who designed an unusual, indeed unique, device to save a lot of the mathematical labour at the data reduction stage.

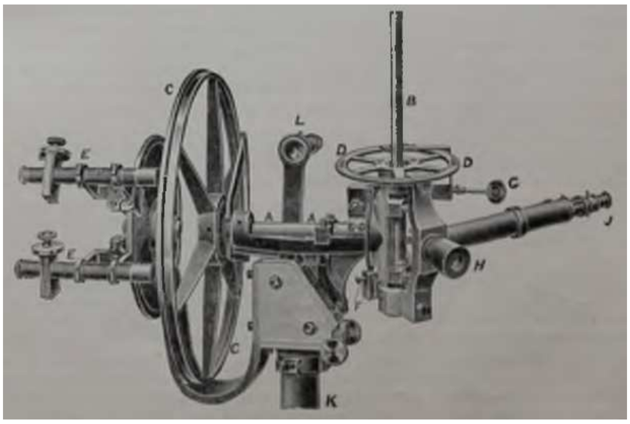


Fig 1. The Kapteyn parallactic measuring apparatus as illustrated in Gill (1913).

In his method, a plate was placed on a stand at a distance from the axis a of the machine, exactly equal to the focal length of the lens of the original telescope (137 cm). It then appeared to be on the same scale as the sky itself. A star image on the plate could be viewed through the telescope consisting of the eyepiece J and objective H (the telescope having a 90 elbow) – see Fig 1. The rest of the apparatus was used for measuring the declination with the circle D and the RA with the circle C. A secondary piece of apparatus held the plates themselves at the required distance. In spite of the simplicity, the precision achieved was better than that of the Northern equivalent, the *Bonner Durchmusterung*, where the stars were measured individually by eye using traditional instruments.

The measurements were made at Groningen and Kapteyn's instrument is still in existence there, in the University Museum. It was proposed to adopt it as the method for measuring the massive quantities of plates produced in the later international survey known as the *Carte du Ciel* (Astrographic Survey) but this idea was rejected in favour of manual measurement using x-y travelling microscopes which were thought to be more accurate.

Repsold/Gill Measuring Machine

Fig 2. The Gill measuring machine, built by Repsold of Hamburg. Two were constructed (SAAO Museum Cat. # M178, # M179).

See "On a New Instrument for Measuring Astrographic Plates" by Gill (1898).

Two of these instruments are in the SAAO Museum. They were Gill's answer to the *Carte du Ciel* question, at least so far as the Cape Zone between declinations −40° and −52° was concerned. They were delivered in 1897 and 1899. For some time, precise grids were imposed on the photographs so that only short offsets had to be measured. Grids were later abandoned.

Repsold plate measuring machine

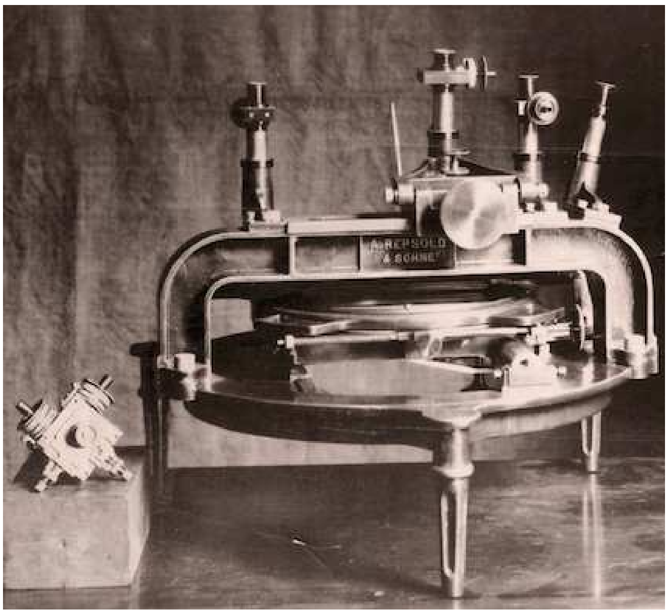


Fig 3. An x-y measuring machine by Repsold of Hamburg (SAAO photo P8793). From its resemblance to Fig 659 in Ambronn (1899) and its evident antiquity this photo may have been taken in Repsold's works.

SAAO possesses or possessed one of these machines. The first one of its kind was made for the measurement of eclipse plates by Repsold for van de Sande Bakhuyzen of Leiden in 1876 (van de Sande Bakhuyzen, MHG, 1892). It is described fully by this author and Ambronn (1899).

Our machine was altered in the 1970s to make it into a ruling engine. It was used to generate masks for the radial velocity spectrometer of the 1.9m telescope by LA Balona and to engrave graticules. Late 19th Century.

Current whereabouts unknown.

Toepfer measuring microscope.

Fig 4. Toepfer measuring microscope in SAAO Museum (Cat. # M149).

There is also an example in "Ingenium: Canadian Museum of Science and Innovation" and dated ca 1904.
Otto Toepfer & Sohn existed in Potsdam 1873-1919.
Housed in a glass and wood case.

Zeiss blink comparator

Fig 5. Zeiss blink comparator. Probably adapted from a viewer for stereoscopic plate pairs (SAAO Museum Cat. # M155).

Zeiss blink comparator, invented by Carl Pulfrich *ca* 1904. Used for comparing plates of the same area taken at different times to locate objects that had moved or changed brightness.

The nearest star, Proxima Cen, was found on a similar but larger version of this instrument by RTA Innes at the Union Observatory, Johannesburg. Unfortunately, Innes's instrument no longer exists.

Fig 6. RTA Innes with the Union Observatory's blink comparator with which he discovered Proxima Cen

in 1915 as a high proper-motion star (SAAO photo P1601).

Fig 7. Stereoscopic attachment for Zeiss Blink. This replaces the blink part (SAAO Museum Cat. # M064). In own wooden box.

Fig 8. X-Y measuring eyepiece believed to be an accessory for Zeiss blink. It appears to be an alternative eyepiece for the blink part (SAAO Museum Cat. # M132). Has own wooden box.

Hilger 2-coordinate plate measuring machine

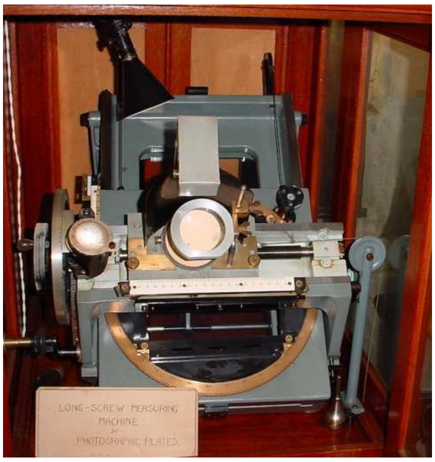


Fig 9. Hilger 2-coordinate measuring machine (SAAO Museum Cat. # M182).

Fig 10. The machine in use, probably in the 1960s (SAAO photo P4281).

Mann 2-dimensional measuring machine.

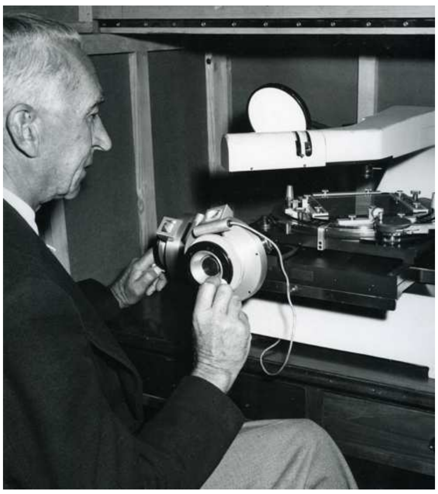


Fig 11. The Mann machine in use, probably in the 1960s. (SAAO photo P4280).

Acquired 1960 or before. Theo Russo at the controls. Parts of the instrument still exist in the Electronics Dept store. According to G. Roberts this machine suffered from backlash in the precision screws.

Zeiss 2-coordinate measuring machine.

Fig 12. Greg Roberts shown operating the Zeiss in March 1986. Photographer unknown (Photo courtesy of G Roberts).

Used mainly for parallax plates and astrometry. Machine no longer in existence.

Grubb Parsons blink comparator.

Fig 13. Remains of the Grubb Parsons Blink Comparator.

Used for finding variable stars. The remains of this instrument were photographed on a rubbish heap, November 2021. Originally purchased by Radcliffe Observatory, Pretoria, ca 1960, and moved to the Cape in 1974. Found in SAAO rubbish dump, Nov. 2021.

Spectroscopic Measurements

The McClean telescope had a multi-prism spectrograph and there was also a large laboratory spectrograph made by the Hilger company. Plates from the telescope normally had calibration spectra from a local gas discharge tube on each side of the star spectra.

The objective prism on the McClean telescope produced spectra of many stars in the field.

The 40-in (1.0m) telescope at Sutherland had the “Yapp” Cassegrain grating spectrograph attached during the early years of Sutherland (1970s) and produced plates with two different scales.

The 74-inch (1.9m) telescope while still in Pretoria had three different Newtonian spectrographs that produced tiny low-dispersion images. Later it was equipped with a large Cassegrain 2-prism spectrograph. The later Cassegrain “Unit Spectrograph” on the 74-inch (1.9m) telescope was used with various image tubes, including a McGee “Spectracon”. Other plates were produced with its coudé spectrograph which has or had several cameras of different focal lengths. Several instruments were specifically for measuring these photographic spectra.

Zeiss double comparison microscope

Fig 14. Zeiss comparison microscope (SAAO Museum Cat. # M037).

For measuring spectra. A precise scale engraved on glass was placed under one microscope and a spectroscopic plate under the other. With own box. It appears in a German lithograph dated 1895.

Hartmann (Pulfrich) spectro-comparator

Fig 15. Hartmann spectro-comparator (SAAO Museum Cat. # M162).

Made by Carl Zeiss Jena. early 20th C. See Hartmann, J., (1906). There are two of these (See also M180). It is in a wood and glass case. The second one has been re-painted. With boxes containing accessories.

Hilger long-screw measuring machine.

Fig 16. Hilger Long-screw measuring microscope (SAAO Museum Cat. # M203, # M204).

Basically a travelling microscope with a precision screw and dial, capable of measuring to about 1 micron accuracy (Several of these, including some from Radcliffe Observatory). These machines were commonly used for measuring spectra at Radcliffe Observatory and the Cape. A 1978 list mentions 4 of them.

Hilger short-screw measuring machine

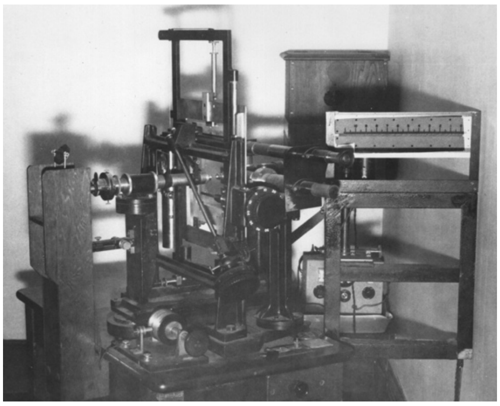
Fig 17. Hilger Short-screw measuring microscope.

Two examples are shown.
These were probably used before the more modern long-screw instruments became available (SAAO Museum Cat. # M148, # M157).

Photographic Photometry

Fig 18. Lady computer working the Schild photometer (SAAO photo P4284).

Fig 19. Schild photometer with scale of mirror galvanometer visible on right (SAAO photo P6576).



Purchased in 1932. This machine played an important part in the photographic photometry programmes of the Cape Observatory in the 1920s to the 1960s. It was modified around 1940 to make it more reliable (see Annual Reports of Director). It no longer exists. Designed in 1922 by J. Schilt (1894-1982).

Askania Iris diaphragm photometer.

Fig 20. Askania (Becker-type) Iris photometer.

This is a double-beam instrument that can be used for measuring transmission through a fixed diaphragm or for measuring the diameter of images using a variable diaphragm. It was in service for photographic photometry at the Cape.
It occupied one of several measuring rooms beneath the MRM telescope and was discarded when these were converted into the Computer Department. Found in the Electronics Department basement store in November 2021.

The principle is described in Stock, J & Williams, AD (1962). Made by Askania-werke, Berlin

Sartorius Iris diaphragm photometer

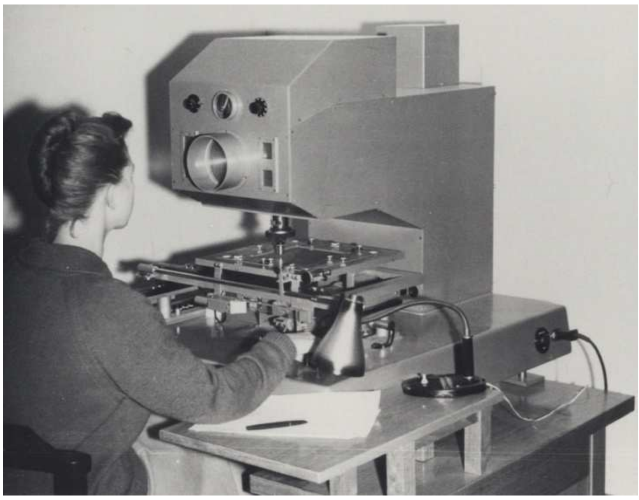


Fig 21. Sartorius Iris photometer (photo: SAAO P4282)

This machine was also used for photographic photometry and occupied one of the measuring rooms below the MRM telescope. It is not known what advantages or disadvantages it had relative to the Askania.

It was probably the instrument purchased by Radcliffe Observatory, Pretoria in 1959 and moved to the Cape when Radcliffe closed in 1974.

It no longer exists.

Plate Digitization

These machines were used to produce digital output from photographic plates such as those from spectrographs and the McMullan electronographic camera.

Joyce-Loebl Autodensidator Mk II #1 Model IIIC Serial No 962.

Fig 22. Left: photo from Joyce-Loebl Mark III CS brochure.

Fig 23. Right: Remains of instrument as found in Electronics basement.

This instrument was originally bought for the Radcliffe Observatory in Pretoria in 1968 and was for digitising spectroscopic plates. The front stage carrying the plate was moved along by a stepping motor. A beam of light transmitted through the plate was compared to a second beam passing through a servo-driven grey filter wedge whose density increased along its length, connected to a pen writing on a second moving stage at the back, mechanically linked to the front one. This produced a scan of the spectrum.

The position of the wedge was also digitized and punched out on a paper tape.
It produced 3 points per second. Supplied with 4 wedges of different densities.
(See SAAO Archives A0376, Joyce-Loebl, Radcliffe sub-file).

Casella Projection Microdensitometer

Fig 24. Casella "Projection Micrometer Machine" (SAAO Museum Cat. # M205).

Used at Radcliffe and moved to Cape Town when Radcliffe closed in 1974.

"This machine was made by Messrs. C.F. Casella and designed by them jointly with members of the staff of the Radcliffe Observatory, Pretoria". See Redman (1939) for a full description.

Joyce-Loebl Autodensidator #2

A Joyce-Loebl Autodensidator Type M Mk IIICS modified to have an x-y stage and a magnetic tape recorder was purchased by SAAO in 1971. I believe that it was interfaced to a Nova 1220 computer and ½-in magnetic tape recorder. It was used for digitizing films generated on the McMullan electronographic camera. The process was very slow due to the semi-mechanical method of density measurement. (See SAAO Archives A0376, Joyce-Loebl, Cape file)

DEMAC Measuring machine

This machine consists of a projector, high up on the wall, for 16 x 16 cm plates and a coordinate measuring table. Its purpose was to identify approximate coordinates of stars of interest for later scanning with the COSMOS machine in Edinburgh. It is still (2021) in place in the store room of the Astronomical Museum in the McClean building.
Ca 1970 (?).

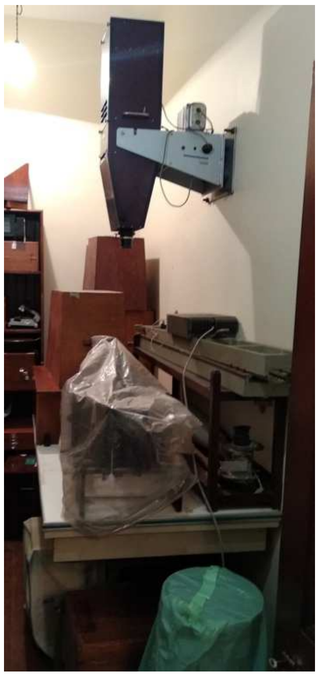


Fig 25. The Demac machine. It consisted of a projector mounted on the wall and a digitizing table (seen here cluttered with other items). It is in a small room now used as the Museum Store in the McClean dome (SAAO Museum Cat. # M181).

Acknowledgments

I thank Mr Greg Roberts, Mr Willie Koorts and Dr Robin Catchpole for comments and contributions.

The photographs in this article are by ISG unless otherwise credited.

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Streicher Asterisms

Magda Streicher

STREICHER 66 – DSH J2056.5-5915
Indus

The relatively bright magnitude 8 star, that could also be a double, listed as HD 198943, is the focus of this unusual grouping with a lovely clump of fainter stars to the north. To complete this group are a few stars in an uneven line towards the southern field.

Object	Type	RA	Dec	Mag	Size
STREICHER 66 DSH J2056.5-5915	Asterism	20h56m.30	-59°15'.30	8.5	7'