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Introduction

The University of Washington Bamberg Transit Telescope was made in approximately 1904 and was built in Berlin, Germany by the Carl Bamberg Company. The serial number of the Bamberg Transit Telescope is 13324. It is called a 'broken' or elbow transit telescope because of its design. The light is reflected by a mirror or prism to the eyepiece. This design has an advantage over the other basic type of transit telescope, where the light travels straight down to the eyepiece, in that the eyepiece is always in the same place. The transit telescope was used as late as the 1950's. Stopping its use coincides exactly with the invention of the atomic clock which suggests that the University of Washington Transit Telescope was used primarily to determine time.

History of the Bamberg Company

As previously mentioned the University Transit Telescope was made by the Carl Bamberg Company. Carl Bamberg was born in 1847. Between the years of 1862-1866 he was an apprentice to Carl Zeiss. Carl Zeiss was a well known and respected for his work in optics. During the years of 1869-1879 Carl Bamberg worked for Pistor and Martins; a company that made scientific instruments. In 1873 he founded his own company and became a curator of the scientific instrument collection of the Imperial Navy. After Carl Bamberg died in 1892, his wife took control of the company. His son took control of the firm in 1904. In 1921 the company merged with another company to form Akania Werke AG. After this it is unknown what happened to the Bamberg company.

Basic Principle of the Transit Telescope

In order to use the Transit Telescope, one must understand the basic principle behind it. The principle behind the Transit Telescope is that when a star passes over the *meridian*[1] its *right ascension* is equal to the *sidereal time* (measured in hours, minutes, and seconds), multiplied by a constant. 1 degree of arc is equal to 4 minutes. This principle is used to determine time.

Methods of observing

There are two different methods of observing with the transit telescope. The first method is the "eye-and-ear" method. In the eye and ear method the observer watches the star and counts the seconds by listening to the clock (A4.7). The observer then records the time that the star passed by one of the vertical lines in the eyepiece. This method is not as accurate as the second method which uses the **chronograph**[2] (A4.8), unless the person doing the observing is experienced in observing with the eye-and-ear method. In this case there is a minimal difference of error between the two.[3]

To use the **chronograph** method the transit telescope must be used with a **chronograph** and in conjunction with a clock. The clock is connected to the **chronograph** and also to the transit telescope. The **chronograph** is a recording mechanism. It is driven using weights and gears. It has two pencil holders on a piece that travels down a track as the drum turns. The drum is covered with smoke paper. One pencil would be connected with the clock and the other with the **micrometer** (A4.1) which is attached to the transit telescope. The pencil connected with the clock will make a tick mark on the paper covering the chronograph drum every second. As the micrometer is turned it completes a circuit every time a vertical line is passed and makes a second

[1] All italicized terms are defined in Appendix 1
[2] All bold terms are defined in Appendix 2
[3] Doolittle <u>Practical Astronomy</u> pg. 283

tick mark. This would allow the observer to know the exact time the star crossed over according to the clock used.

Uses

The transit telescope has several uses. One of the main astronomical uses came before the atomic clock when the transit telescope was used to correct the drift of mechanical clocks. It was not until the atomic clock was put to use that time could be kept standard without the use of an instrument like the transit telescope. In order to correct time an observer would examine a star with a known *right ascension*. This *right ascension* could be converted into time. The transit telescope gave the time that the star passed over the *meridian* according to the clock being used. By using the time given by the star's *right ascension* and noting what time it passed according to the clock**,** the clock could be corrected. After the creation of the atomic clock in the late 1950's, the use of an instrument like the transit telescope was no longer necessary.

The transit telescope also had surveyor uses. It could be used to determine latitude and longitude. By using a Sun filter a surveyor could use the Sun's angle, time, and the current date to accomplish this. Without a Sun filter, surveyors would use a known star such as Polaris. The transit telescope would be used to find the angle of *declination* of the sun/star. Polaris is the easiest one to use because it is almost always in the same position. The angle of the **setting circle** (A4.2) is approximately the latitude when looking at Polaris.

Currently transit telescopes are being used to map the sky. These are much larger than the Bamberg transit telescope because they are made see more than one star. Since the transit telescope can observe one section of the sky at a time, it is perfect for mapping the sky.

How to use the University of Washington Bamberg Transit Telescope:

Step 0: (Before Observing)

Before getting ready to observe it is necessary to find the *declination* that the star should pass over. Once this is done it is necessary to adjust for the latitude of the observatory which is roughly 47°25' for the UW Campus Observatory. This would be a close approximation to the place where the star would pass. If the telescope has to be adjusted while observing then the **zenith level(**A4.4) would give the adjustment value.

Step 1:

Open the roof. First open the south end and then the north end. (East and west is labeled on the telescope base which can be used to determine north from south.) The side panels should also be opened, but they are currently painted shut. This opening in the roof marks the north/south *meridian* over which the stars are observed with the transit telescope.

Step 2:

Remove the glass from the telescope. This is done after the roof is opened so that no dust will fall down and damage the telescope while the roof is being opened. Also remove the lens cap from the top of the telescope while it is in the down position.

Step 3:

Unlock the **venier level(**A4.1) and rotate it around the setting circle until it is at the appropriate reading for the star that is to be examined and clamp it into place. Once it is clamped into place the **precision screw** can be used to help reduce errors. If the star is in the northern sphere the telescope will have to be rotated about its axis using the **reversing lever** because the venier level cannot rotate all the way around the setting circle before it hits the **micrometer**.

Step 4:

Unlock the **zenith level** and the telescope. Hold the zenith level horizontal until the **venier level** is also horizontal then clamp the zenith level and the telescope in place. This points the telescope at the place on the meridian the star will pass. It is important that **zenith level** is horizontal because the *declination* is approximated and the telescope may have to be adjusted once observation has started. If the telescope has to be adjusted the value that the **zenith level** gives is the amount the telescope has moved. The **venier level** should not be readjusted once observations have begun. The scale for the **zenith level** is 1.33 seconds of arc (Note; this value is based on previous research).

Step 5: (observing)

Once the telescope is in place check to make sure the **micrometer** is in the appropriate position. (The small **gradient lines** (A4.2) are at zero). Then turn one of the three knobs. (Note: When recently tested, all of the knobs turn the lines. It is unknown if this is a malfunction or if it is supposed to happen). The star should pass through the two horizontal lines (A3.2). If it does not pass through the horizontal lines then adjust the telescope. The **dimmer knob** (A4.6) can be used to give more or less light to illuminate the wires.

Step 6:

When done place the lens cap back on and place the telescope back down. Then place the glass back on and close the roof in the opposite order they were opened.

Future

One future prospect for a transit telescope is a program called LUTE. LUTE is the Lunar Transit Telescope project that was founded in 1990. The goal of LUTE is to place a transit telescope on the Moon to map the sky. This would avoid light pollution and would also be able to take data all day long. This would require a worldwide network to gather and interpret all the data that would come in. These are some of the pluses to putting a transit telescope on the Moon.

While there are several benefits about a telescope on the Moon there are also a couple problems that arise. There is a lot of dust on the Lunar surface. This dust is sharp and abrasive, and can damage the instrumentation. The largest problem with the Moon is the wide range of temperatures it undergoes. During the day the average temperature is 107 degrees Celsius and at night it is -153 degrees Celsius. If a transit telescope were placed on the Moon it would have to endure the wide range of temperatures on Moon. At the moment these problems encountered with the Moon and the cost problems are still being researched.

Unresolved Issues with University of Washington Bamberg Transit Telescope

The University of Washington Bamberg Transit Telescope currently cannot be used to observe. This is because there are several things still unknown about the transit telescope and things that are currently not working.

- The mirror/prism on the inside is dirty and therefore light does not travel through very well.
- The part where the light bulb attaches appears to be missing. While the appropriate light bulbs are in the observatory, there does not appear to be a direct way to attach one to the end of the transit where they would have gone.

- The clock that should attach to the **chronograph** does not work. At some point in time an electric motor was added to it. The motor no longer runs.
- The telescope is no longer electrically attached to the chronograph. What needs to be done to solve this problem is unknown.
- The **chronograph** itself still runs; but one of the springs has fallen off and it is unclear as to where it attaches.
- There is a piece that belongs to the transit telescope that replaces the one where the light bulb would go. The piece where the light bulb would go (A4.3) is easily removed by pulling it off. This additional piece fits on in its place, but it is unknown what it would do or if it should go on the other end.

Parts: The letters coincide with the diagram A3.1

Chronograph

Is a recording mechanism. It records every second from when it is turned on in accordance with the clock. A second tick mark is made when a star passes over one of the verticle lines in the mircometer. (Note: this is not in the diargram picture; but can be found on A4.8)

A) Dimmer Knob

Dims the light that illuminates the wires in the reticule.

B) Faden Feld (Rough translation: Thread field**)**

This is on the back side of the telescope. It covers and uncovers a small mirror in the telescope. This mirror has a small hole in it. In this manner the knob changes the aperture of the hole and the amount of light that can pass through.

C) Small Gradient Lines (Micrometer)

These are used to give a decimal point to the measurement of the micrometer.

D) Light Bulb

This would go opposite the micrometer. It is used to illuminate the wires in the micrometer that would otherwise be impossible to to see against the darkened sky.

E) Magnifying Eyepiece

This is on the setting circle it magnifies the small graduated lines, used to set the telescope, in order to get the best accuracy.

F) Micrometer (Recording)

Sends electric pulses from the transit telescope to the the chronograph.

G) Precision Screw (Setting Circle)

This allows the observer to change the position of the venier level by a minute amount for better precision.

H) Knob (Micrometer)

Used to track the star as it passes over.

I) The Reticule:

Located in the eyepiece. It consists of two horizontal lines that mark the center of field; and an odd number of vertical lines which are used to mark when the star's position and time of crossing should be recorded. The star should pass midway between them.

J) Reversing Level:

Allows the telescope to be reversed on it's axis.

K) Setting Circle:

Small graduated circle that is used to point the telescope.

L) Striding Level:

Tube usually filled with alcohol or sulfuric ether that is used to determine if the axis is horizontal.

M) Switches

These turn complete the circuit for the micrometer and the light bulb.

N) Vernier Level:

Level on the setting circle which is used when pointing the telescope.

O) Zenith Level:

Two levels on the same mounting. This is used when an adjustment has to made while observing. 1.33 seconds of arc is the approximate scale per unit for the level.

Declination:

One piece of the coordinate system used to position a star in the sky. It is like that of latitude on Earth and ranges from 0 to 90 degrees. The angle above or below the celestial equator.

Meridian:

Passes through the north and south. Like longitude. Marks a star's highest point in the sky.

Right Ascension:

One piece of the coordinate system used to position a star in the sky. It is like that of longitude on Earth. Ranges from 0 to 360 degrees or 0 to 24 hours.

Sidereal Time:

Time given in hours, minutes and seconds relating to the stars. The star's right ascension when passing over the meridian is equal to this time.

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