THE LIPPMANN COELOSTAT

THE MECHANICS AND SIDEREAL DRIVE

A Lippmann coelostat keeps the reflected sunlight (or starlight) fixed in direction by rotating a plane mirror continuously about an axis parallel to the Earth's rotation axis.

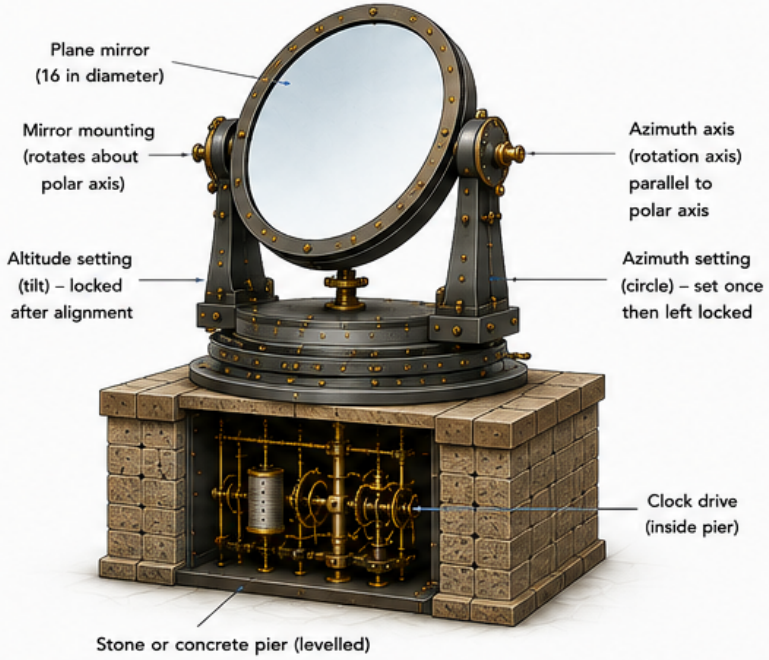
The mirror is driven by a weight-driven clock mechanism so that it turns at exactly half the sidereal rate.

This compensates for the apparent daily motion of the Sun and keeps the telescope seeing a stationary field.

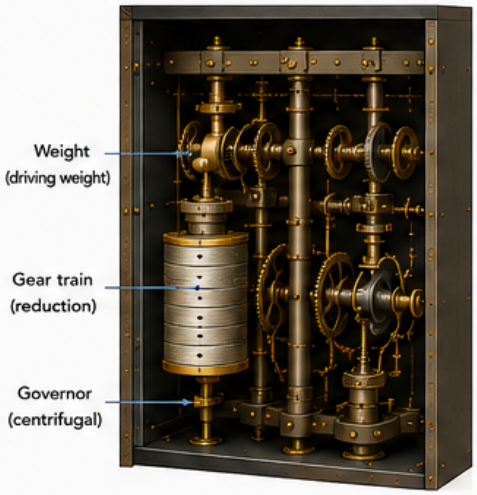
KEY FACTS (1919 COELOSTAT)

- Mirror diameter: 16 in (40.6 cm)
- Axes: parallel to Earth's rotation axis
- Drive: sidereal rate ÷ 2
  = 7.5° per hour (one rev in ~48 h)
- Accuracy: ~1 arcsecond
- Purpose: keep reflected beam and telescope field fixed during exposures

1. THE LIPPMANN MECHANISM (OVERVIEW)



2. THE SIDEREAL CLOCK DRIVE (HALF RATE)

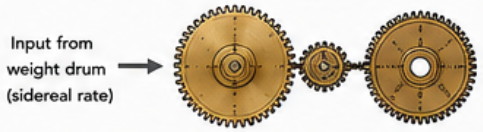


A falling weight drives the clockwork. The gear train reduces the input rate (sidereal rate) by a factor of 2 so that the output shaft (to azimuth axis) turns at half the sidereal rate.

A centrifugal governor automatically adjusts the drive to keep the rate constant despite the falling weight and changing load.

The drive runs for many hours on one winding.

GEAR TRAIN (SCHEMATIC)



Overall reduction = 2 : 1 (sidereal ÷ 2)

3. THE SIDEREAL RATE AND HALF RATE

The Earth makes one rotation relative to the stars in one sidereal day.

Sidereal day = 23 h 56 m 4.091 s
= 86,164.091 s

Sidereal rotation rate = 360° / 23 h 56 m 4.091 s
= 15.041067° per hour

Coelostat mirror rate = half of this
= 7.520533° per hour
= 0.1253422° per minute
= one revolution in 48 h (approx.)

Why half? A rotation of the mirror by an angle ϕ changes the reflected direction by 2ϕ. To cancel the Sun's apparent motion of θ, the mirror need only turn by $\theta/2$.

TIME	SUN'S APPARENT MOTION (OVER STARS)	MIRROR ROTATION (½ SIDEREAL)	REFLECTED BEAM DIRECTION
0 h	0°	0°	Fixed
6 h	~90°	~45°	Fixed
12 h	~180°	~90°	Fixed
18 h	~270°	~135°	Fixed
24 h	~360°	~180°	Fixed
48 h	~720° (2 rev)	~360° (1 rev)	Fixed

As the Earth turns, the Sun's direction changes by ~15° per hour. The clock drive turns the mirror by ~7.5° per hour in the same sense. The reflected beam therefore remains fixed.

4. HOW IT OPERATES

1 Set the coelostat

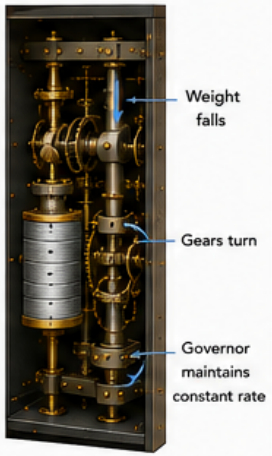
- Level the pier.
- Set the altitude (tilt) for the Sun's declination.
- Set the azimuth circle to the correct hour angle.
- Point the telescope to the reflected beam and focus.

2 Start the clock

- Wind the drive and release the brake.
- The weight begins to fall and the gear train turns the azimuth axis at half the sidereal rate.

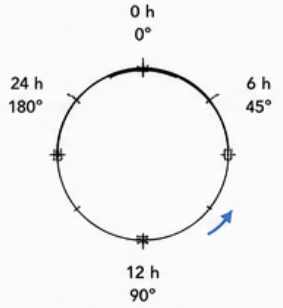
3 During the exposure

- The mirror rotates smoothly.
- The reflected beam stays fixed and the telescope field remains stationary.



5. TIMING AND PERFORMANCE

ROTATION OVER TIME (MIRROR)



PERFORMANCE

- Rate accuracy: ~1 arcsecond
- Run time on one winding: many hours (typ. > 12 h)
- Backlash in gears: extremely small
- Bearings: jewel or hardened steel of very low friction
- Alignment: axes truly parallel to the polar axis

SUMMARY

The Lippmann coelostat uses a precision clockwork drive running at half the sidereal rate to rotate the mirror about an axis parallel to the Earth's rotation axis. This exactly compensates for the Sun's apparent motion so that the reflected beam – and the telescope field – remain fixed for long photographic exposures.