The Sundial Cities

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Keywords: Engineering survey;Implementation of plans;Positioning;Spatial planning;Urban renewal;

SUMMARY

When observing in our modern cities the sun shade gliding along the large surfaces of buildings and towers, an observer can notice that after all the local time could be deduced from the position of the sun. The highest building in the world - the Burj Dubai - is de facto the largest sundial ever designed. The principles of sundials can be understood most easily from an ancient model of the Sun's motion. Science has established that the Earth rotates on its axis, and revolves in an elliptic orbit about the Sun; however, meticulous astronomical observations and physics experiments were required to establish this. For navigational and sundial purposes, it is an excellent approximation to assume that the Sun revolves around a stationary Earth on the celestial sphere, which rotates every 23 hours and 56 minutes about its celestial axis, the line connecting the celestial poles. Since the celestial axis is aligned with the axis about which the Earth rotates, its angle with the local horizontal equals the local geographical latitude. Unlike the fixed stars, the Sun changes its position on the celestial sphere, being at positive declination in summer, at negative declination in winter, and having exactly zero declination (i.e., being on the celestial equator) at the equinoxes. The path of the Sun on the celestial sphere is known as the ecliptic, which passes through the twelve constellations of the zodiac in the course of a year. This model of the Sun's motion helps to understand the principles of sundials. If the shadow-casting gnomon is aligned with the celestial poles, its shadow will revolve at a constant rate, and this rotation will not change with the seasons. This is perhaps the most commonly seen design and, in such cases, the same set of hour lines may be used throughout the year. The hour-lines will be spaced uniformly if the surface receiving the shadow is either perpendicular (as in the equatorial sundial) or circularly symmetric about the gnomon (as in the armillary sphere). In other cases, the hour-lines are not spaced evenly, even though the shadow is rotating uniformly. If the gnomon is not aligned with the celestial poles, even its shadow will not rotate uniformly, and the hour lines must be corrected accordingly. The rays of light that graze the tip of a gnomon, or which pass through a small hole, or which reflect from a small mirror, trace out a cone that is aligned with the celestial poles. The corresponding light-spot or shadow-tip, if it falls onto a flat surface, will trace out a conic section, such as a hyperbola, ellipse or (at the North or South Poles) a circle. This conic section is the intersection of the cone of light rays with the flat surface. This cone and its conic section change with the seasons, as the Sun's declination changes; hence, sundials that follow the motion of such light-spots or shadow-tips often have different hour-lines for different times of the year, as seen in vertical gnomons such as obelisks. The author will review the principles of designing and processing the hourly lines of a sundial were the gnomon will be part of building edges and how surveying and astronomy are joining together to produce elegant artworks. A way to contribute a new kind of cities ... the sundial cities.

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