THE FORMAL ANALYSIS OF PANTHEON IN ROME IN RELATION TO THE SOLAR ANGLES

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The form of Pantheon in Rome is graphically analyzed in relation to the angle of the Sun that varies through four seasons of the year. These are worked out in the Autocad drawing files for exactitude and efficiency. Some of the results suggest that the Pantheon is carefully designed to predict the equinoxes and the solstices.

1. Forewords

The interior of the Rotunda is solely lit by the sunlight through the Oculo, an opening at the crown of the dome. The Rotunda and its portico are oriented toward due north. From these facts it seems appropriate to assume that the composition of forms that comprise Pantheon may somehow be related to the angles of the Sun. I have already carried out a similar study on the Pyramids of ancient Egypt, another perfect set of examples of orientation toward due north, and explained their various slopes in relation to the specific dates when their northern faces began or ended to be lit by the sun.[1]

The longitudinal section, the floor plan and the ceiling plan of Pantheon shown here are scanned from a booklet 'Pantheon', written by Flaminio Lucchini,[2] and then inserted to make new Autocad drawing files. But the scanned drawings are inserted only in one of the drawings here, because of their magnitude of file memory. The discrepancies in the basic dimensions exist among the various texts, and I had to make a number of assumptions such as:

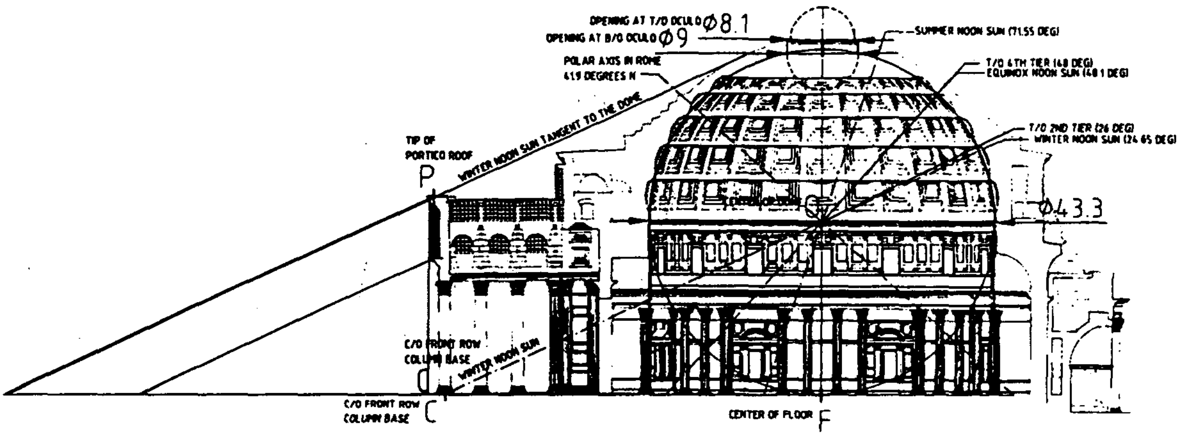
1) Lim Choking Shin, Insolation Phase of the Pyramids, Journal of KAAH(Korean Association of Architectural History) V.1-No.1(1992.6), pp.205-217

2) Flaminio Lucchini, Pantheon, La Nuova Italia Scientifica, pp.50, 51, 64, 90

(1) The dome is assumed to be a perfect hemisphere with a diameter of 43.3 meters.[3]

(2) The floor of the Rotunda is 21.65 meters, or a half of the diameter of the dome, below the base of the dome, therefore, tangent to the imaginary sphere of the dome.[4]

2. The Solar Geometry centered at the Center of Dome



(DWG-01) SOLAR ANGLES AT THE CENTER OF DOME - Section

The angle of the noon sun on the winter solstice from the center of dome falls very closely to the center of front row column base at the portico(Point C of Dwg-01), although it does not have any particular relevance in respect of the true sunlight. It also falls near the top of the second tier of coffers.

The angle of the winter solstice noon sun tangent to the rotunda roof falls very closely to the tip of the portico roof (Point P of Dwg-01). This means that the shadow of the round rotunda roof, which is visible in the fore-ground only during the winter season, moves northward getting closer to the triangular shadow of the portico roof as the sun gets lower, and it almost overlaps the latter at the noon of the winter solstice.(Dwg-06)

The celestial equator, i.e. the meridian of the equinox sun, falls very close to the top of the fourth tier of coffers.

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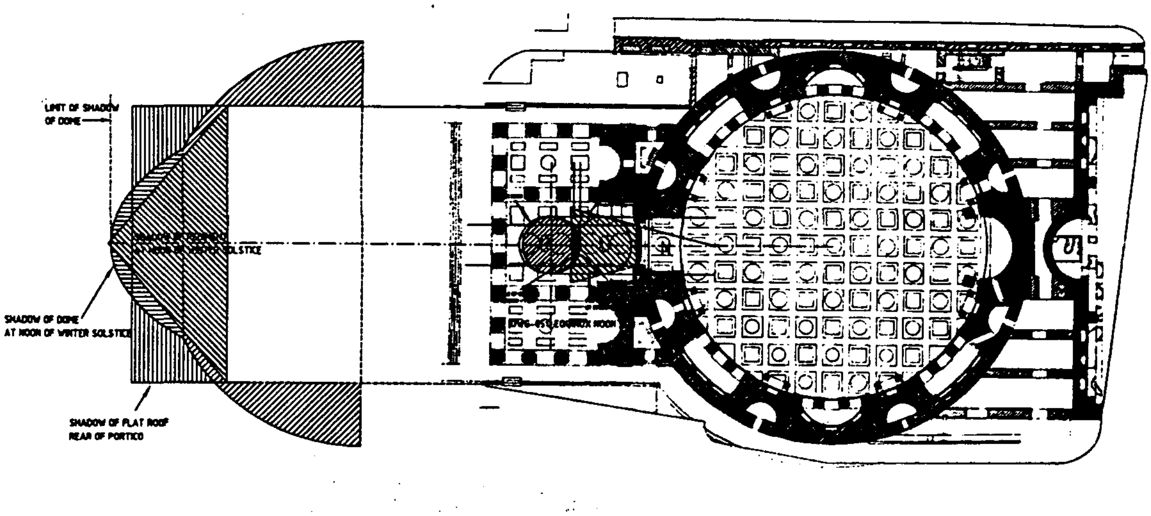
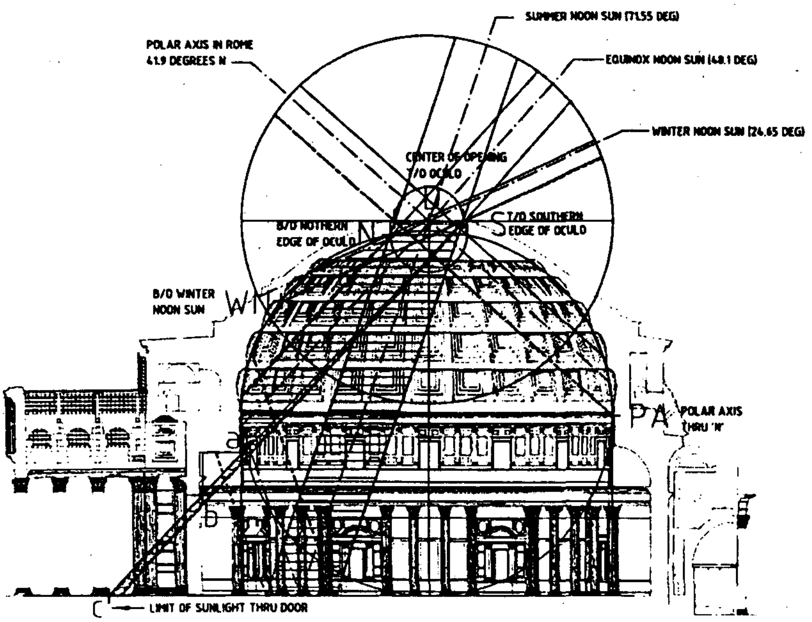
3) The diameter of the dome is 142'-6", or 43.18 meters according to Fletcher, 42.2 meters according to Klassen, etc.

4) No drawings of Pantheon from existing publications exactly match this notion, and even Lucchini's drawing does not match his own idealized section.



(DWG-06) WINTER SOLSTICE NOON SHADOW - Plan

3. The Solar Geometry centered at the Center of Oculo

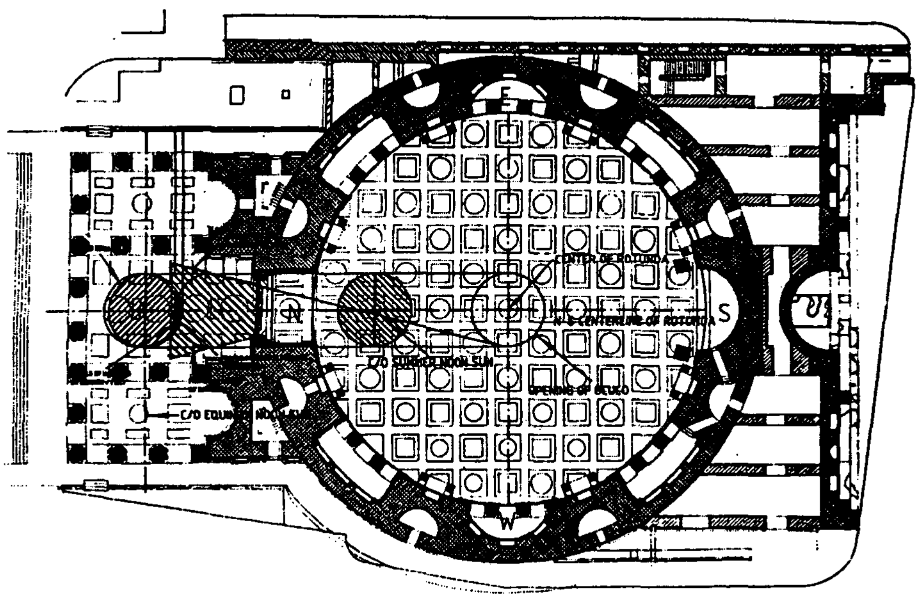


(DWG-02) SOLAR ANGLES AT THE CENTER OF OCULO - Section

The drawing (Dwg-02) shows the solar geometry centered at the center of oculo.

The Polar Axis through the northern edge of the Oculo (Point N), 41.9 degrees above the horizon in Rome, falls very closely at the southern edge of the base of dome (Point PA). The lower edge of the winter solstice noon sun disk falls at the top of the third tier of coffers, which means that, on the winter solstice, the sunlight through the oculo hangs high in the ceiling and never gets lower than that. The equinox noon will be discussed later in detail.

4. A special considerations on the Equinox Noon Sun

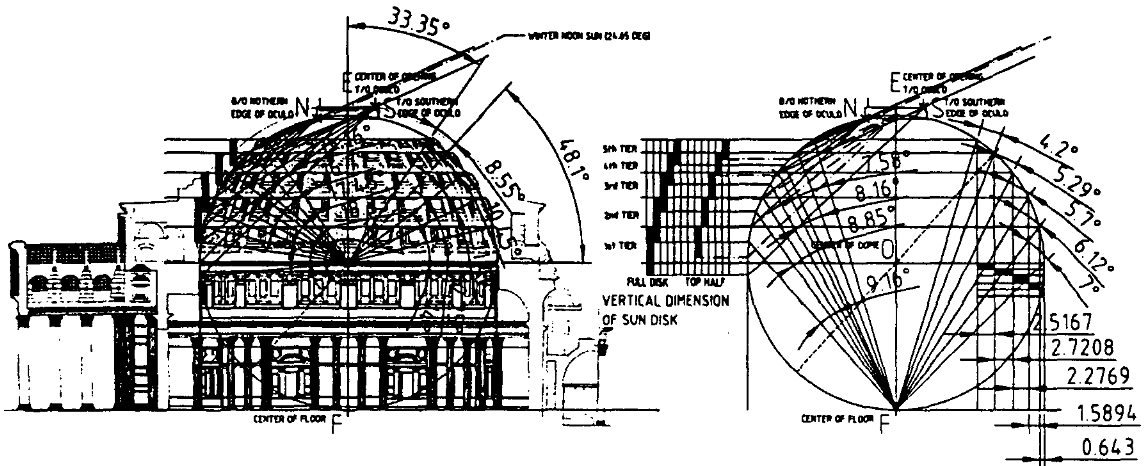


(DWG-05) EQUINOX NOON SUN - Plan

The drawing (Dwg-5) shows the top view of equinox noon sun disk outside the doorway of rotunda. As the season approaches the vernal equinox, the track of sun disk descends below the base of dome. Just a day or two prior to the vernal equinox, to be exact, a slice of sunlight goes through the doorway and hits the floor outside it. On the equinox noon, it moves closer to the door, but its outer side is cut by the profile of arch at the doorway, thus forming an arc cut by another.

As the sun gets higher, it grows larger to make a complete circle, but then cut by the vertical door jambs. The phase of change reverses itself as the time approaches autumnal equinox, and the sunlight disappears completely from the floor on the second day after the autumnal equinox.

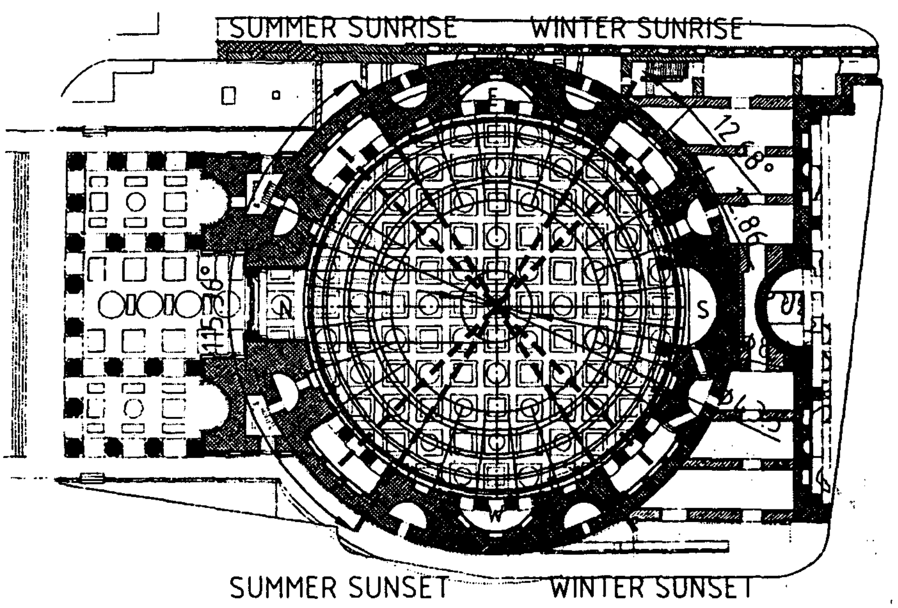
5. Arrangement of Coffers



(DWG-03) ARRANGEMENT OF THE COFFERS - Section

The Drawing (Dwg-03) shows the arrangement of coffers and their angular relations in the sectional view. The vertical dimension of each tier is rather related to the projection of sunlight on the ceiling of the dome. The disk of sunlight, i.e. the angular projection of Oculo on the sphere of dome, lights approximately one and a half tiers of coffers all the time. More specifically, the upper half of the light-disk always covers one tier of coffers. The lower half of the light-disk is much shallower because the cornice of Oculo cuts its lower profile. These notions, however, leave much to further investigation because exact dimensions are not available at this time.

The Drawing (Dwg-04) shows the arrangement of coffers and their angular relations in the top view. The four azimuths of the solstice sunrise and sunset coincide with the radial division lines, so do the 45 degree diagonal division lines. The angle between the two sets of lines is 12.68 degrees, which is very close to the 28th division of a circle, i.e. 12.86 degrees. Therefore the radial division of coffers into 28 each is a mathematical conclusion if one intends to align coffers to the two sets of lines mentioned above. Number of 28 also coincide with the Roman day-count of a sidereal month[5] and, though probably unrelated, to the Asiatic division of the zodiac.



(DWG-04) ARRANGEMENT OF THE COFFERS - Plan

6. Conclusions

(1) Pantheon as Time Reckoning Device

As explained in chapter 4, the form of Pantheon is carefully designed to predict, or to reckon the days of the equinox and the solstice, particularly of the equinoxes and the winter solstice. The reckoning of the equinox could be very precise because the solar declination changes much faster during equinox season. It changes at the rate of 0.4 degree a day, and the track of sun disk moves almost 0.5 meter a day. The floor pattern in front of the doorway may have something to do with it. Author could not get into it because of lack of precise dimension in the available drawings.

The sign of winter solstice is less distinct because the change rate of the solar declination is almost nil compared to that of the equinox, and the change of shadow would be imperceptible. The shadow Pantheon would extend as far as 55 meters in front of the portico provided that the plaza is flat and open. As the year proceeds to the winter solstice, the shadow of rotunda would gradually proceed toward that of the pediment, and, on the winter solstice day, it would stop just short of overlaying the former. This much would be perceptible.

5) Vitruvius, (trnsl.) M.H.Morgan, Ten Books on Architecture, Dover 1960, 28 days and an hour (Vitruvius), 27.32 days (Astronomical), 29.5 days (Synodic Month) , p.258

There is another sign of winter solstice within the rotunda. The track of sun disk ascends toward the upper part of the dome as the year proceeds to the winter solstice, and its lower profile will go up as far as the top of the third tier.

(2) Arrangement of Coffers

The tiers of coffers are not foreshortened in regard to their angular view from the floor as suggested by Fletcher, but they are so arranged according to the radial extent of the sun disk projected on the spherical ceiling. The sun disk always extends as many as one and a half tiers of coffers as a result. The horizontal division of coffers into 28 could be a result of applying the two sets of angles; one referring to the azimuth of the solstice sunrises and sunsets, and the other to the usual quadruple division of a circle. The difference is mere 0.18 degree. The number of 28, after all, is the number of days of a lunar month according to Vitruvius.

References:

1. Lim Choking Shin, Insolation Phase of the Pyramids, Journal of KAAH(Korean Association of Architectural History) V.1-No.1(1992.6)
2. Flaminio Lucchini, Pantheon, La Nuova Italia Scientifica
3. Vitruvius, (trnsl.) M.H.Morgan, Ten Books on Architecture, Dover 1960

로마 판테온의 일조특성 연구

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국문초록

로마의 판테온은 고대 로마 시대의 건축 유구 중에서 그 원형을 가장 잘 유지하고 있는 건축물 중의 하나이다. 많은 부분이 헐리거나 다시 지어졌음에도 불구하고 대형 로툰다와 벽체, 그리고 포티코는 아직도 원래의 장중한 모습을 그대로 지니고 있다. 직경 43.3M의 로툰다 내부는 그와 같은 높이인 돔 상부에 뚫려있는 직경 8.1M의 '눈'(Oculo)을 통해 들어오는 햇빛만으로 밝혀진다.

판테온은 정 남-북으로 방위를 잡았고 포티코는 로툰다의 정 북 방향으로 놓였다. 어떤 건축물이 정 방위하는 것은 그 자체로 매우 특이한 일이다. 이집트의 피라미드, 메소포타미아의 지구라트 등이 그러한 예에 해당한다. 이는 개략적인 정 방위와는 근본적으로 다른 배치 개념인 것이다. 필자는 그 중에서도 특히 정 남-북 방위를 잡은 경우는 일사각과 뗄 수 없는 관계가 있다고 믿는다.

이집트의 피라미드가 정 사각추 라는 단순한 기하학적 형태를 지닌 것처럼 판테온도 구형 및 원통형이라는 단순한 기하학적 형태를 지녔다. 돔 상부의 '눈'을 통해 들어오는 원형의 햇빛은 마치 규칙적으로 돌아가는 탐조등처럼 하루하루 로툰다 내부를 비추며 돌아간다. 햇빛은 당연히 규칙적으로 돌아가는 것이다. 그렇다면 햇빛과 판테온의 형태 사이에 어떤 관계가 있을 수 있으리라고 추정할 수 있다.

필자는 이러한 관계를 찾기 위해 scanning한 판테온 도면 위에, autocad로 로마의 위도에 맞춘 해의 궤적도를 그리는 작업을 했다. 기대했던 만큼의 결과는 아니었지만 다음과 같은 결론을 얻을 수 있었다.

(1) 포티코 앞쪽 지붕 정점은 동지일 정오 돔의 그림자와 만난다.

(2) 포티코 앞쪽 기둥열의 평면상 중심선은 돔의 입체적 중심에서 그린 동지일 정오 해의 고도각과 일치한다.

(3) 춘, 추분 정오, '눈'을 통해 들어오는 햇빛은 로툰다 출입구 아치를 지나 포티코 바닥에 특이한 형태의 빛을 만든다. 이는 춘, 추분 정오에만 만들어지는, 아치의 원호와 '눈'의 원호가 만나서 만드는 특이한 형태의 빛이다. 여기서 판테온이 춘, 추분을 정시(定時)하기 위한 일종의 해시계였다는 가설이 성립될 수 있다.