Em Hotep
Egypt for the Curious Layperson and the Budding Scholar

Hemienu to Houdin: Phase One, Part C— The Inner Working of the Great Pyramid

Posted by: Shemsu Sesen (Keith Payne) – April 2011

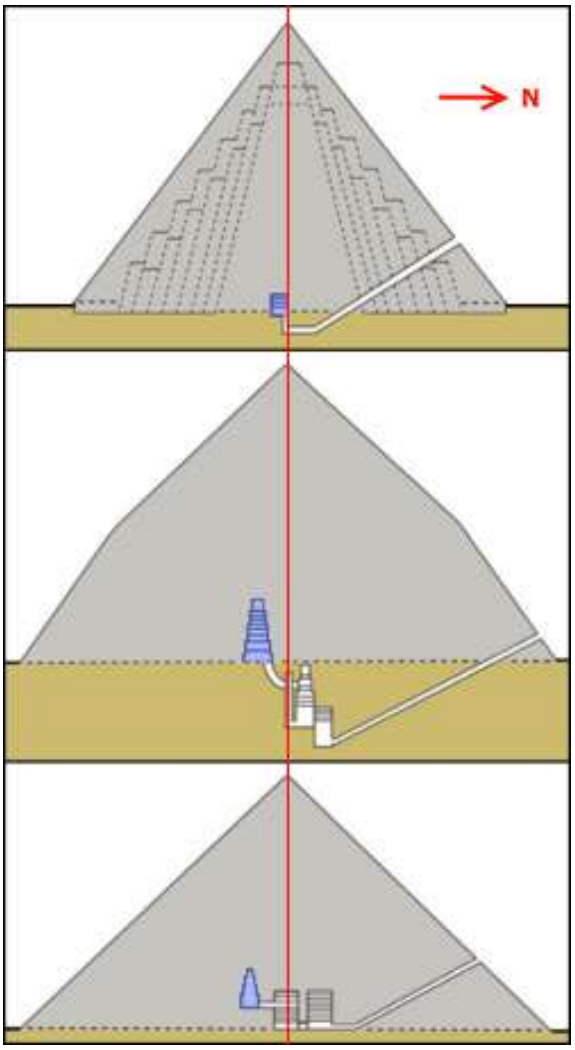
The Layout: A Vertical, Rather Than Horizontal, Design

With conventional architectural designs, we are accustomed to seeing floor plans that are laid out on the horizontal plane. Interconnected rooms are arranged on the same level, joined by doorways or horizontal corridors. If there are other levels, then these too are arranged in horizontal space, with stairs, ramps, or elevators connecting the levels. This is true of the majority of architecture in ancient Egypt as well. But with the Great Pyramid things are a little different.

Although pyramids are the most celebrated funerary structures from the Old Kingdom Period, most people who could afford a luxurious send-off were interred in, or more accurately, under, a mastaba. Mastabas were flat-roofed rectangular brick buildings that were aligned north-to-south. They sat atop one or more vertical shafts cut into the bedrock that led to subterranean burial chambers. By the Fourth Dynasty, the peak of the Pyramid Age, mastabas could be rather elaborate in design.

Pyramids were in many ways a royal upgrade of the mastaba. In fact, the earliest pyramid that we know of, the Step Pyramid of Djoser, began as a large mastaba and ended as five additional mastabas stacked on top of the original, with each level smaller than the previous. Another innovation is that the burial chamber moved progressively higher as pyramids evolved—from underground, to ground level, to end above ground level within the core.

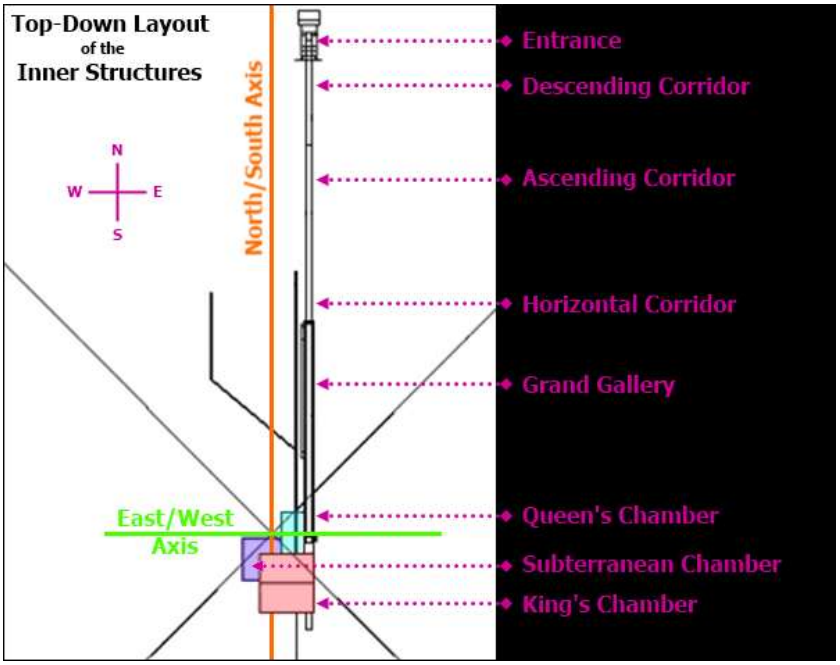
Khufu's pyramid has three different burial chambers at three different levels. Hemienu had his reasons for constructing these burial chambers at different levels, not to mention at different phases of construction, and we will get into these details a little later in this article. But their arrangement within the pyramid's structure—the need to have them at different levels, but with similar alignment and orientation—is part of why the floor plan of the Great Pyramid is designed on the vertical, rather than horizontal, plane.



Convention during this period dictated that royal burial chambers should lie to the south of the pyramid's east/west axis. As shown in the illustration, the burial chambers in the Meidum, Bent, and Red Pyramids are all constructed south of the east/west axis, opposite the entrance. In Khufu's pyramid the King's and Subterranean Chambers both lie to the south, and the Queen's Chamber straddles the east/west axis perfectly.

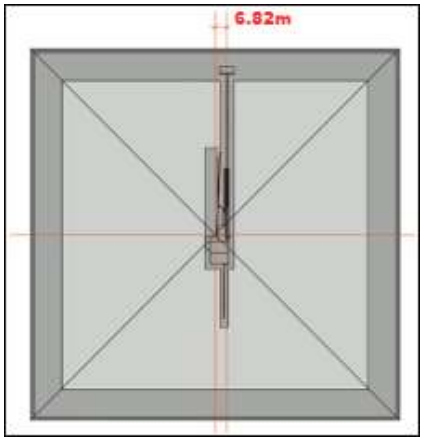
In the case of the Queen's Chamber, the intent may have been for the sarcophagus to be placed in the southern half of the room, had it been used for the pharaoh's interment. Such exact placement has precedence within the Great Pyramid, as the sarcophagus in the King's Chamber is arranged with its eastern side perfectly aligned with the north/south axis. But even without knowing the exact reasons why, we do know that the three chambers are clustered around the midpoint of the pyramid at different levels, and the straight approach from the northern entrance makes for an easy vertical arrangement.

One way of thinking about the inner structures is to consider that movement is from north to south. The Entrance is on the northern face. From there one progresses southward via the Descending Corridor. At 28.2 meters inside, the Ascending Corridor branches up and continues southward from the Descending Corridor, which continues its own southerly journey to the Subterranean Chamber. The Ascending Corridor ends at the base of the Grand Gallery, with a Horizontal Corridor leading off to the Queen's Chamber. Both the Grand Gallery and the Horizontal Corridor continue southward. The King's Chamber is the highest and southernmost known internal structure.



The vertical arrangement of the internal structures also had practical benefits. Recall that most of the pyramid—the core—is made up of rough-cut blocks, filler chips, and gypsum mortar. These blocks are made of the same locally quarried nummulitic limestone as the backing layer, but are not as precisely calibrated and were not suitable as a foundation for the inner structures. The burial chambers, and especially the earth-rattling counterweight system that would be housed in the Grand Gallery, required a solid foundation of the same well-cut masonry that makes up the backing layer.

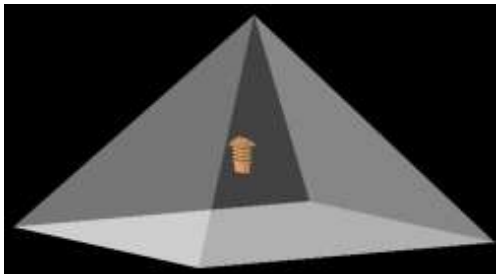
These more precisely cut blocks were expensive in terms of the time it took to shape them and the materials expending in doing so. Each well-cut block required more copper chisels, more runners to carry the dulled chisels from the worksite to the sharpeners, more wood (a rarity in the desert) to keep the smith's fires burning, and most of all, more time. Nothing in the Great Work of Khufu's Pyramid could be wasted, especially time, so ideally the inner structures needed to be squeezed into as small a footprint as possible—the smaller the footprint, the less expensive the foundation.



For all of these reasons it made sense to design the inner workings of the Great Pyramid on the vertical rather than horizontal plane. Rather than rooms located on the same level and connected by horizontal passageways, Hemienu stood the floor plan on its edge. The rooms would be aligned vertically on different levels, connected mostly by sloping corridors. This vertical structure could rest on a shared foundation that was a simple north-to-south strip of pavement.

Before we continue on to our description of the individual elements of the inner workings of the Great Pyramid, let's first address why Hemienu might have constructed three burial chambers, and why they couldn't have been built on more or less the same level within the pyramid.

In the Event of Untimely Death: The Provisional Burial Chambers



Putting aside all symbolism, and ignoring Hemienu's personal ambitions, the Great Pyramid was ultimately built for one purpose only: a final resting place for the body of Pharaoh Khufu. Everything about how the pyramid was planned and executed revolved around the final burial room known as the King's Chamber, and its unique flat ceiling. But the King's Chamber would not be complete until Year 15 of construction. What if the King, gods forbid, died before that?

Hemienu had planned for such a contingency. The Great Pyramid was designed from the outset to have three burial chambers: the King's Chamber and two provisional tombs. The first provisional tomb was the Subterranean Chamber, which would serve as a temporary tomb if Khufu had died during the first ten years of construction. The second provisional tomb was the so-called Queen's Chamber, which would have held the pharaoh's body if he died during years ten through fifteen. After that the king would have been interred in the King's Chamber while the pyramid was completed.

It has been argued in the past that the three different burial chambers suggest that Hemienu had altered his plan as he progressed, originally intending the Subterranean Chamber to be the tomb, then deciding to locate the burial room at the higher location of the Queen's Chamber, then ultimately deciding to build a third, final burial room—the King's Chamber. However, the precision with which the King's Chamber was located argues against this and in favor of a single, complete building plan from the very beginning.

We will be expanding on the evidence for Hemienu's fore planning when we cover Phase Two, but for now consider that the placement of the "great step" at the top of the Grand Gallery *exactly* on the east/west axis, and the ceiling of the King's Chamber *exactly* at the one third height of the finished pyramid, could only have been achieved with comprehensive planning. The length and height of the Grand Gallery are not arbitrary, as we shall see, and to know in advance where the great step would be located meant that Hemienu knew exactly where, and at what slope, to begin the Ascending Corridor.

For these reasons alone we can be certain that the Great Pyramid was planned with three different burial chambers from the outset. The idea of Hemienu making radical alterations, such as adding entire rooms and corridors after construction had begun, simply does not reconcile with the exactitude of the finished product. Planning for temporary burial chambers seems to be more in the character of Hemienu from what we can deduce from the meticulous planning which must have gone into each phase of construction. We will now look more closely at the individual elements of the inner structure.

The Descending Corridor

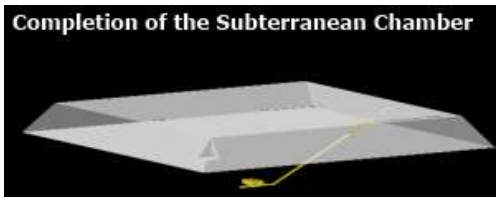
Work on the Descending Corridor would have begun in the very earliest stages of pyramid construction, while the foundations were still being leveled. It started as a passageway cut downward into the bedrock, .96 meters (3.1 feet) high and 1.04 meters (3.4 feet) wide, descending southward at a 26.5 degree angle. Work on the Descending Corridor would have continued while the first courses of the pyramid were being laid, with the corridor being extended upward into the new masonry toward the future Entrance in the northern face of the pyramid.

Rather than the rough-cut blocks of the core, the masonry into which the Descending Corridor was extended was the well-calibrated blocks of the foundation being laid for the rest of the internal structures.

This may have contributed to the precision with which the Descending Corridor was constructed—Jean Pierre has noted that it is the most precisely cut structure within the pyramid, never deviating more than a quarter of an inch its entire run (Brier and Houdin p. 79).

Once finished, the Descending Corridor passed downward through the masonry for 28.8 meters, continued through the bedrock for another 30.3 meters before leveling off at a depth of 30 vertical meters below ground. After a short (8.9 meters) horizontal stretch the Descending Corridor ended at the Subterranean Chamber, for a total run of about 68 meters.

The Subterranean Chamber



Thirty vertical meters below the ground, the Subterranean Chamber was the first of the two provisional tombs, and is where the body of Khufu would have been temporarily interred if he had died during the first ten years of construction. It has been noted that the Descending Corridor is too small for a sarcophagus such as the one located in the King's Chamber (Lehner, p. 111), which makes sense if the Subterranean Chamber was intended only as a temporary burial chamber. It is likely that his body would have rested here until the superior Queen's Chamber was finished after Year 10, and then finally moved to the King's Chamber after Year 15.

Fortunately, Khufu never had use for it, as evidenced by its incomplete state. The walls and floor are "in the rough," and it is likely that, seeing that the king was in good health, and having completed enough of the Subterranean Chamber that it could have been finished during the mummification process if needed, Hemienu decided that further work on the first provisional tomb would be a waste of effort.

The Subterranean Chamber has irregular dimensions, but measures roughly 8 by 13 meters, with a height of about 3.1 meters, and is oriented east to west, with the northern wall aligned on the east/west axis. The chamber also contains an unfinished "well shaft" and what appears to be an unfinished continuation of the horizontal section of the Descending Corridor exiting through the south wall. The purpose of the pit and the southern extension are unknown, however, it is worth observing that if Hemienu *did* make alterations to his plan, the subterranean section—not being part of the pyramid's superstructure—was the only safe place to do so.

The Entrance

Located at the opposite end of the Descending Corridor, the Entrance is pretty self-explanatory—it was the original means of entrance into the Great Pyramid. The Entrance is located seventeen meters above the base and is centered 6.82 meters east of the north/south axis. This 6.82-meter offset has to do with the need to align the Grand Gallery with the eastern half of the King's Chamber. We will sort out these details when we cover Phase Two, but the simple explanation is that the heavy beams of Aswan granite were unloaded on the eastern side then positioned to the west.

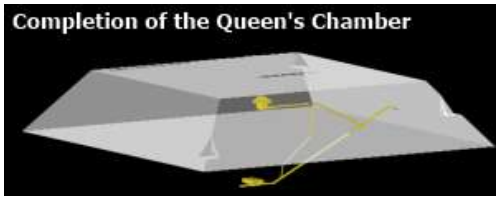
Speaking of heavy beams, the Entrance is supported by four 20-ton blocks of Tura limestone that would have been the first heavy test of the external ramp. These huge blocks are situated in two pairs, one on top of the other, with the paired blocks resting against each other at a 120 degree angle. The effect is an impressive double gable that has become one of the iconic images of the Great Pyramid. These megalithic blocks are the same that are used to form the arched ceilings of the Queen's and King's Chambers.

The Ascending Corridor

The Ascending Corridor begins as an upward branch of the Descending Corridor at about 28 meters in from the Entrance. This cramped passageway starts literally as a hole in the ceiling of the Descending Corridor, and shares the same dimensions (.96 by 1.04 meters) and slope (26.5 degrees). At about 39 meters in length, the bottom of the Ascending Corridor is currently plugged by three large granite blocks, each 1.5 meters long.

We will be revisiting the Ascending Corridor when we cover Phase Two. Jean-Pierre Houdin theorizes that this passage originally housed a ballast roller that was part of the counterweight machinery of the Grand Gallery, the floor of which is a continuation of the slope of the Ascending Corridor. Like the Descending Corridor, the Ascending Corridor is housed in the strip of well-calibrated masonry that forms the interior foundation. It is in perfect vertical alignment with the Entrance, sharing the same 6.82 meter offset.

The Queen's Chamber



By Jean-Pierre's analysis, the pyramid should have reached a height of 21 vertical meters around Year 8 of construction, which was an important milestone. At this elevation the Ascending Corridor came to an end and the Grand Gallery began. Also at this junction a horizontal passageway was constructed leading to the south. With a length of 21 meters, this Horizontal Corridor led to the second provisional tomb, the misnamed "Queen's Chamber." This was to be the temporary resting place of Khufu's body, if needed, from Years 10 through 15.

Unlike the King's and Subterranean Chambers, the Queen's Chamber is longer from north to south, 5.75 meters, than it is east to west, 5.23 meters. This may give the initial impression that, unlike the other burial chambers, the Queen's Chamber is oriented north to south rather than east to west. But the innovative ceiling of the Queen's Chamber, a sort of trial run for the roof of the relieving compartments above the King's Chamber, puts this notion to rest.

Unlike the corbelled ceilings of previous pyramid burial rooms, the ceiling of the Queen's Chamber is formed by six arching pairs of 20-ton rafters of Tura limestone identical to the gables above the Entrance. Leaning in at 120 degrees to rest against each other, these beams form a peaked ceiling 4.6 meters above the floor of the Queen's Chamber. This apex not only runs east to west, it perfectly straddles the east/west axis of the pyramid, leaving no doubt that the Queen's Chamber, like the King's and Subterranean, is oriented east to west.

As mentioned above, the arching ceiling of the Queen's Chamber probably served as a proving ground for Hemienu, as he would later use the same structure atop the relieving compartments of the final burial room. The King's Chamber is unique in that it has a flat ceiling, an innovation with possibly aesthetic and/or symbolic significance, but which required a good deal of compensation elsewhere in the pyramid's structure. In order for the King's Chamber to have a flat ceiling, Hemienu needed to divert the weight above it elsewhere, and these powerful gabled ceilings were key parts of the solution.

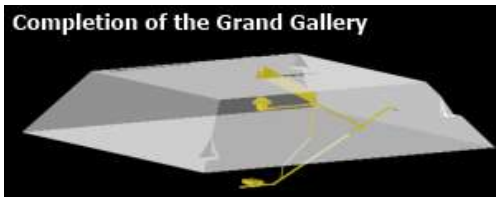
Of course, the reinforcement of the narrow internal foundation was also an important factor in the stability of the inner structures, and like the rest of the Great Pyramid's "plumbing," the Queens Chamber was aligned along this runway of masonry.

There are other elements of the Queen's Chamber which may have served structural or symbolic purposes, or possibly both. Situated in the eastern wall is a corbelled niche nearly as tall as the room itself which Mark Lehner believes may have once held a statue of Khufu, making the Queen's Chamber a serdab (Lehner, pp. 111-12). This theory, however, is not incompatible with the idea of a provisional burial chamber. There is no reason why the room could not have held the king's body while the pyramid was finished, only to be sealed off as a serdab upon completion.

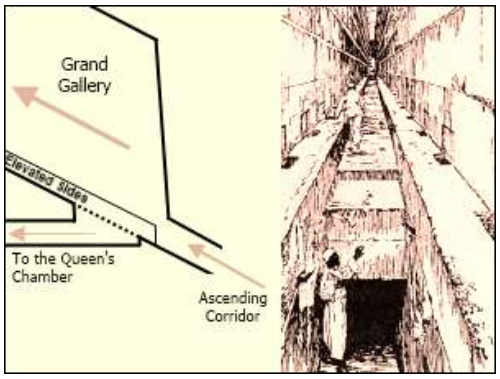
Another interesting feature is the so-called air-shafts, two diagonal shafts leading out of the Queen's Chamber through the north and south walls. Jean-Pierre theorizes that these shafts were an intercom system that allowed the foremen working on the north side of the pyramid to communicate with those on the south side. This would have been particularly useful during Phase Two, when the noise level from the counterweight system and the need to coordinate would have been at their highest. The fact that these shafts terminate at the same level that Phase Two ended seems rather telling.

By Year 9 of construction the ceiling of the Queen's Chamber was in place, with the tip of the rafters reaching about 24 meters above the base of the pyramid. As with the first provisional tomb, Hemienu did not bother finishing the walls and ceiling of the Queen's Chamber as it seemed apparent Pharaoh Khufu would not need it, and if he did, there would again be plenty of time to finish it while the king was mummified. But even as the Queen's Chamber was being constructed the rest of the pyramid continued to rise, including the Grand Gallery, which also had its base at the 21 meter level.

The Grand Gallery



So to recap, by Year 10 there were three completed passageways. One was the Descending Corridor leading from the Entrance down to the Subterranean Chamber, the first provisional tomb. The second was the Ascending Corridor, branching up from the Descending Corridor and which ending at the 21-meter level. The third was the horizontal passageway that led due south from the top of the Ascending Corridor to the Queen's Chamber, the second provisional tomb. The junction at the 21-meter level is where the Ascending Corridor transitions into the Grand Gallery.



Visualizing the junction at the top of the Ascending Corridor can be tricky business, as the Horizontal Corridor leading to the Queen's Chamber is at the top of the Ascending Corridor and essentially tunnels under the Grand Gallery. The floor of the Ascending Corridor resumes at the same 26.5 degree incline opposite the gap formed by the beginning of the Horizontal Corridor. This gap is flanked by two elevated sides, or "benches," that run nearly the entire length of the Grand Gallery from the base to the top.

In total, the Grand Gallery is about 46 meters long and 8.6 meters high from floor to ceiling, with a total vertical height of 17.35 meters from the bottom (above the gap that allows access to the Horizontal Corridor) to the top of the great step. The base width (including the benches) is 2.06 meters. The walls are corbelled with seven tiers, extending inward about 7.6 centimeters at each tier, giving the ceiling a width of 1.04 meters. The benches are each about 51 centimeters wide and about 61 centimeters high, squeezing the floor of the Grand Gallery into a trench about 1.06 meters wide.

There are enigmatic particulars about the Grand Gallery, not the least of which are its unusual dimensions and topography, which suggest a purpose beyond a simple passageway. Mechanical details, such as the regular notches that run the length of the benches and the unusual wear pattern of the great step (now mortared over) provide clues that some sort of large-scale kinetic activity once took place in the Grand Gallery. The solid base provided by the internal foundation indicates the Hemienu planned for heavy bodies in motion. Like the external ramp, the Grand Gallery was designed with durability in mind.

We will explore Jean-Pierre Houdin's explanations for these details and a great many others as we unfold the mysteries of Phase Two: the construction of the King's Chamber. With the external ramp completed and the fiftieth course of the Great Pyramid leveled off at a clean 43 meters, Hemienu was ready to plug the external ramp into its battery—the counterweight trolley that thundered along its tracks in the Grand Gallery. This ancient machine, fully integrated into the structure of the pyramid itself, provided the extra muscle required hauling the great beams of granite into place above the King's Chamber.

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