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THE GEOMETRY AND CONSTRUCTION OF THE GREAT PYRAMID

by Arthur E Hartley

> *The usages and customs among Freemasons have ever borne a near affinity to those of the Ancient Egyptians.*
>
> Ritual of the Western Australian Constitution.

> *That which is expressed by the soul of the West is expressed by the soul of Old Egypt almost exclusively by the immediate language of Stone. Instead of forming hypotheses and number-systems and dogmas, it set up its huge symbols in the landscape of the Nile, in all silence. Stone is the great emblem of the Timeless; space and death seem bound up in it. Men have built for the dead before they have built for the living, and even as a perishable wooden structure suffices for the span of time that is given to the living, so the housing of the dead for ever demands the solid stone of the earth. The oldest cult is associated with that stone that marks the place of burial, the oldest temple-building with the tomb-structure. The origins of art and decoration with the grave-ornament. Symbol has created itself in the graves. That which is thought and felt and silently prayed at the grave-side can be expressed by no word, but only hinted by the boding symbol that stands in unchanging grave repose. The dead strive no more, and hence it is stone, the abiding stone, that expresses how the dead is mirrored in the waking consciousness of the living.*
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> Oswald Spengler on the Egyptians' view of death,
> from *The Decline of the West*, vol I, p 18.

Facts about the Great Pyramid

The above quotation from the Ritual of the Western Australian Constitution indicates the worth of Egyptian studies to the understanding of the origins and history of the Craft. It invites further research into the mysteries of that ancient culture, perhaps to trace some indications of the origins of Freemasonry. There is a lodge room in Sydney where the walls are decorated with Egyptian hieroglyphics. It would be of interest to discover the origins of this 'Room' which was known as the 'Egyptian Room'. Especially interesting would be some translation of the meaning of the symbols.

Much of the culture of Ancient Egypt has been lost during the course of centuries of occupation. Some interest was aroused during the French invasion of Egypt by the armies of Napoleon. The discovery and subsequent translation of the Rosetta Stone provided a key to the language and made some of the history of Ancient Egypt available. The surviving buildings and monuments give to the modern world an intimation of the life and thought processes of that epoch. Paramount among these resources are the pyramids at the head of the Nile delta in the neighbourhood of Cairo.

The Great Pyramid of Cheops was constructed around the year 2900 BC, It was authorised and promoted by the ruler after whom it was named and it must be considered as one of the longest-surviving monuments in the history of mankind. It is conceivable that Cheops supported its construction with funds as well as assisting in the organisation of the labour force, but the design and the supervision were the charge of an extremely intellectual caste who were the counterpart of the priestly class of medieval society. A tradition exists of the invasion of the Nile valley about 3000 BC by a population of people of supreme intellect, who in the course of a century converted Egypt from an agricultural community into a powerful state, with an advanced culture expressed in language, art, mathematics, architecture, engineering and, hydraulics.

A few facts about the pyramid will convey some indication of the colossal nature of the task of the building, taking into consideration the limitations under which the workmen and the architects operated.

1. The base area is a square of 230.3 metres covering an area of 5.3 hectares or 13 acres.
2. The North–South orientation of the east and west sides is accurate to within one twelfth of a degree.
3. The volume of stone used in the construction of the pyramid itself is 2.6 million cubic metres. The ramps that are reputed to have been used would have doubled this figure.
4. The pyramid was originally covered with casing blocks of white limestone, the average weight of which was 2.54 tonnes. Considerable accuracy was required in the shaping and setting of these blocks. They were removed by a later ruler for the building of his Imperial Palace.
5. It has been estimated that one hundred thousand men were employed in the quarrying transporting and setting of the blocks. The auxiliary work force supporting the construction amounted to another one hundred thousand.
6. The building was carried out during the periods of the flooding of the Nile, a time when the land was under water and agricultural activities were limited. It is probable that the pyramid building was promoted partly by the need to find useful work for unemployed farm workers.

Inside the Great Pyramid

The entrance to the pyramid was sealed by a granite plug. This plug was lowered vertically into position when the building was completed, and was designed to prevent any grave-robbers from entering and removing the treasures with which the mummified bodies had been entombed. Many of the pyramids were destined to be the places for resting the bodies of those of the dead who could afford that expense. However, there is doubt that the Great Pyramid was ever used as a tomb.

An entrance had been made by grave-robbers into the north side of the pyramid by circumventing the granite plug. Access was thus gained to the descending passage, 105 metres in length, and at a slope of one in two, or 26.6 degrees. From the bottom the descending passage levelled out for 7.6 metres, leading to an underground pit directly below the apex of the pyramid. At a distance of 18.3 metres down the descending passage it branched into an ascending passage 40.8 metres in length, where it branched again into a horizontal passage leading to what has come to be known as the Queen's Chamber. This chamber has been calculated to be at the gravity-centre of the pyramid, and is 110 metres below the apex. There is no evidence that the Queen's Chamber was intended for a tomb; it was not the custom in Ancient Egypt to incarcerate the bodies of the Kings and Queens in the same tomb.

The Grand Gallery, which is a continuation, at the same slope, of the ascending passage, has been described as one of the great architectural feats of the Ancient World. Its length is 47 metres, height 8.53 metres and width at the base of 1.57 metres, narrowing through a series of corbelled walls to a width of 1.04 metres. There are ramps along the whole length and these are .45 metres in width and .6 metre in height. There are 27 slots cut vertically at regular spacings in the lower part of the walls .The ceiling is composed of slabs overlapping from the bottom and these were removable during the course of the building. It is supposed that the Grand Gallery was so designed that, during the twenty or more years while the building was under construction, the opening in the ceiling was used to map the transit of the stars and planets. This enabled the priest-architects to calculate, with the use of the clepsydra, or water-clock, the length of the year in solar and sidereal time. This also enabled them to estimate the circumference of the Earth at latitude 31 degrees, as well as the circumference over the north and south poles.

Where the ascending passage meets the Grand Gallery, a well has been cut descending almost vertically, leading to a roughly cut grotto, and then continuing at an angle of 60 degrees to meet the descending passage at a point 90 metres within the entrance. It is supposed that this could have been an escape passage for the workmen following upon the blocking of the Grand Gallery and the ascending passage.

The Grand Gallery continues upward at a slope of 26.6 degrees to a ramp over which entrance is obtainable to an antechamber, and into what has been named 'The Kings Chamber'. This chamber measures 12.2 metres in length by 6.1 metres in width and is 6.8 metres in height. The proportions are significant, being 2 by 1 by half the square root of five. The Chamber is encased with huge granite blocks and the ceiling is composed of five layers of granite. Each of these weighs several tonnes, and they are spaced 1.25 metres apart, forming smaller chambers, the uppermost of which is roofed in gabled form. The purpose of this structure could have been to protect the chamber from the depredation of grave-robbers, but it is reputed never to have been used as a tomb.

Inside the King's Chamber is an empty sarcophagus without any lid. If King Cheops had been incarcerated here, his body must have been subsequently removed; but there is opinion that the entombment never took place. Two vents have been made from the King's Chamber; one points to the north face at an angle of 31 degrees, (the angle of the latitude of the pyramid). It is therefore parallel to the axis of rotation of the Earth; and points to the Polar Star. The other ventilation shaft points to the south face at an angle of 45 degrees, pointing to the star Sirius, in the constellation of Orion.

There are two other ventilation shafts leading from the Queen's Chamber to the north and south faces of the pyramid, but their orientation does not appear to serve any purpose. It is claimed that when these shafts, from both chambers, were cleared of debris the temperature from both chambers was maintained at a constant level. This has led to further speculation that the pyramid was used as a receptacle for the weights and measures used at this period, and which would neither deteriorate nor change in the temperature and atmosphere of the interior of the pyramid.

The process of building

Quarried stone was reputedly carried from hundreds of kilometres up the Nile, down through the cataracts. After unloading, the blocks were hauled by human labour, along prepared pavements, to the site. It has been calculated that six men would have been required to haul one block of 2½ tonnes along level ground. Many more would have been needed on the ramps, for the slope was of one in three, or 20 degrees.

At the completion of the building the amount of material in the ramp, depending upon its width, would have approached in volume of material almost to that of the pyramid itself. Moreover, with the addition of each course to the pyramid there would have been a need for alteration to the ramp. Its removal after the completion of the building would have added considerably to the total labour effort.

The use of scaffolding for the placement of the capstone and the upper tiers has been considered by researchers. There is some evidence that the Egyptian builders made use of scaffolding, but the shape of the pyramid would have presented difficulties. Though ropes, woven from reeds, were used in Egypt, there is no evidence of the invention of systems of pulleys. Wheeled vehicles for heavy haulage were not in use.

It is logical to suppose that the white limestone casing blocks would have been placed into position at the commencement of the construction of each tier. Their cutting would have been the work of the more skilled workmen and their shape would have required the use at each block of an implement to measure 90 degrees and another to measure 51.83 degrees, the angle of slope of the sides. Their emplacement would have required the maintenance of the same angle of slope on each face of the building for a height of 186.5 metres. The accuracy achieved with such masses of stone is a tribute to the skill of architects and masons.

As the structure rose, allowance for the building of the chambers and the passages and for the Grand Gallery would have to be taken into account . Granite blocks surrounding the Grand Gallery and the King's Chamber weigh up to 70 tonnes each, and the material was so hard and dense that only diamond-tipped tools could have cut it. The only metals available to the Egyptians were copper and tin; bronze was made from an alloy of these two metals, but this would not have been of sufficient

hardness to cut the more dense stone. In the quarries, rocks were split by the use of wooden wedges driven into the stone and split by soaking the wedges with water. This does not explain the shaping of the granite slabs and the plugs sealing the Grand Gallery, which would not have responded to this treatment.

Recent research by a professor of engineering in the United States suggests that much of the material in the pyramid was cast on the spot, as with modern concrete structures. His theory is well documented and he has had practical experience in the casting of stone for building. His opinions and theories have been published and are available for public scrutiny. The technique that he described explains many of the problems of the building, particularly of the existence of material too hard for cutting, and of the shaping of the casing blocks with such accuracy that no gap can be discerned between adjacent blocks. Analysis of some of the blocks suggests that they were cast in position with an agglomerate that hardened quickly, using the face of the adjacent block as part of the cast. The random appearance of small shells throughout the blocks supports the theory of casting, as in a sedimentary stone such shell material would appear in layers. Egyptian officials in charge of the pyramids are not encouraging further research into this matter.

Professor Davidovits proposed also that the casting of stone was made possible through the use of a chemical substance mined in the Sinai Peninsula. After the building of the other two pyramids at Cairo, the supply of this substance was exhausted and the building of further pyramids of the same pattern was therefore not undertaken.

What was gained from the building?
The millions of man-hours spent in the design and construction of the pyramid will bring to mind the possible return that could have accrued to those responsible for the project. What alternative avenues of investment of labour and capital were there in the production of what might have been castigated as ‘a heap of stones’? Undoubtedly the building of pyramids was an attractive undertaking for Cheops, as it was for those of his successors who built pyramids on a somewhat smaller scale. In the erection of these great monuments the motive of vanity cannot be dismissed, though alternative purposes might be discerned and other gains could emerge.

The Great Pyramid served as a sundial and calendar in that land of clean air and cloudless skies. Excavations are reported of markings on the adjacent ground where the shadow of the apex would have appeared at certain times of the days and years. When the receding floods of the Nile left the land bare, without trace of the landmarks that had indicated areas of cultivation, the two pyramids of Cheops and Chefren provided reference points for the surveyors to re-establish titles. The Great Pyramid, situated at the head of the Delta of the Nile is visible for 30 kilometres around and would have served the needs of surveyors over an area of five thousand square kilometres.

There appears to be some evidence, accepted by the compilers of the Masonic ritual, of the ceremonial rites enacted by the priests of Egypt. The interior of the pyramid appears designed as a place for the enactment of secret rites. The three chambers, the pit, the Grand Gallery, the Second Chamber, situated in the gravity centre of the building, the antechamber leading to the King’s Chamber and that chamber itself, the constant star visible by night and day through the ventilating shaft, and the sarcophagus, support the view that the pyramid could have been a temple for the enactment of secret rites.

Paramount in importance is the geometrical feat achieved in the many proportions of the building by the priest-architects. The Egyptians were geometers, and their investigations led them to the study and utilisation of dimension and direction. In this respect they differed from the Babylonians who were able to use the abstraction of number. Some of these abstractions were available to the Egyptians and among these were the Pythagorean triangle with sides of 3, 4 & 5, and the right-angled isosceles triangle with sides 1, 1, & $\sqrt{2}$. The dimensions of the pyramid indicate clearly that they must have been familiar with the Golden Section of a line, which is $\sqrt{5}$-1, divided by two, or .61803. The square root of this number is .78615.

Importantly this ratio of .78615 is very close to the ratio of the vertical height of the pyramid to its sloping height, and this ratio was certainly known to the architects. The angle formed by the triangle incorporating these dimensions (51.83 degrees), was used by the skilled masons for measuring the casing stones There is ample justification that the architects were erecting a monument to the solution of the problem that had baffled the early masons, that is the calculation to the ratio of 'pi'. The proportion of a quarter of 'pi', known as 'phi', can be calculated geometrically by the superposition upon the pentagram of the triangle involving the Golden Section. Such a triangle must have been available to the masons who cut the casing-stones. When it is realised that the proportion of 1 **:** .78615 is a very near approximation to a quarter of 'pi', the proportions and dimensions of the pyramid become of great significance in the history of architecture. The ratio of a quarter of 'pi' as calculated by modern mathematics is .78540 so that the degree of accuracy is within one part of a thousand.

The resemblance of the conjunction of the Golden Section Triangle and the pentagram, to the emblem of the Square and the Compasses, is significant. The compasses, opened to an angle of 72 degrees, or the fifth of a circle, is the angle of the pentagram. The hypotenuse of the Golden Section Triangle, involving the square root of .61803 will give the ratio of .78615 or 'phi'. The geometry of the pyramid is convincing proof that early masons were familiar with this close approximation. The geometry of the Great Pyramid suggests strongly that a symbol resembling the Square and Compasses was used and transmitted in a corrupted form to the Masonic institution.

Some close approximation to 'pi', given by the conjunction of the Golden Section Triangle and the pentagram, could have been a cherished secret known to the architects of Egypt and closely guarded by the Master Builders of the Temple of Jerusalem.

The evidence of Dr Leadbeater of his having taken part in a Masonic meeting in Ancient Egypt during a previous existence will, of course, be treated with caution by those who reject the principles of metempsychosis. Nevertheless it has been quoted in the proceedings of the premier research lodge of England, *Ars Quatuor Coronatorum*, and the theory is held by a very large religious community. Like the significance of the Square and Compasses as an approximation of 'pi', the experience of Dr Leadbeater might be accepted as a working hypothesis that the customs and usages of the ancient Egyptians did also bear a close affinity to the ritual practices of modern Freemasonry. There are more things in Heaven and Earth than are dreamt of in our philosophies.

Metempsychosis and Dr Leadbeater

Quoted from the transactions of Quatuor Coronati Lodge No 2076 EC (*AQC* 108:259):

> I did not know any more than any other candidate, what to expect when I joined you, but my first sight of a Masonic Lodge was a great and pleasant surprise to me. because I found that I was perfectly familiar with all arrangements which I knew six thousand years ago in Ancient Egypt.
>
> I am quite aware that this is a startling statement, yet I assure you that it is literally true. And you will observe that this is not a matter about which any mistake is possible, it is not a case in which co-incidence will serve as an explanation. The arrangement of your three chief officers is a remarkable one — not one which would naturally be the first to occur to men trying to compile a ritual. Your symbols are significant and distinctive, and their combination is peculiar; yet they all belonged to Ancient Egypt, and I knew them well there.
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> You may imagine how surprised and delighted I was to find the old work still going on after so many ages. You have kept almost all the ceremonies unchanged through these thousands of years. There are certain minor points of difference which I notice, but they are really only minor points.

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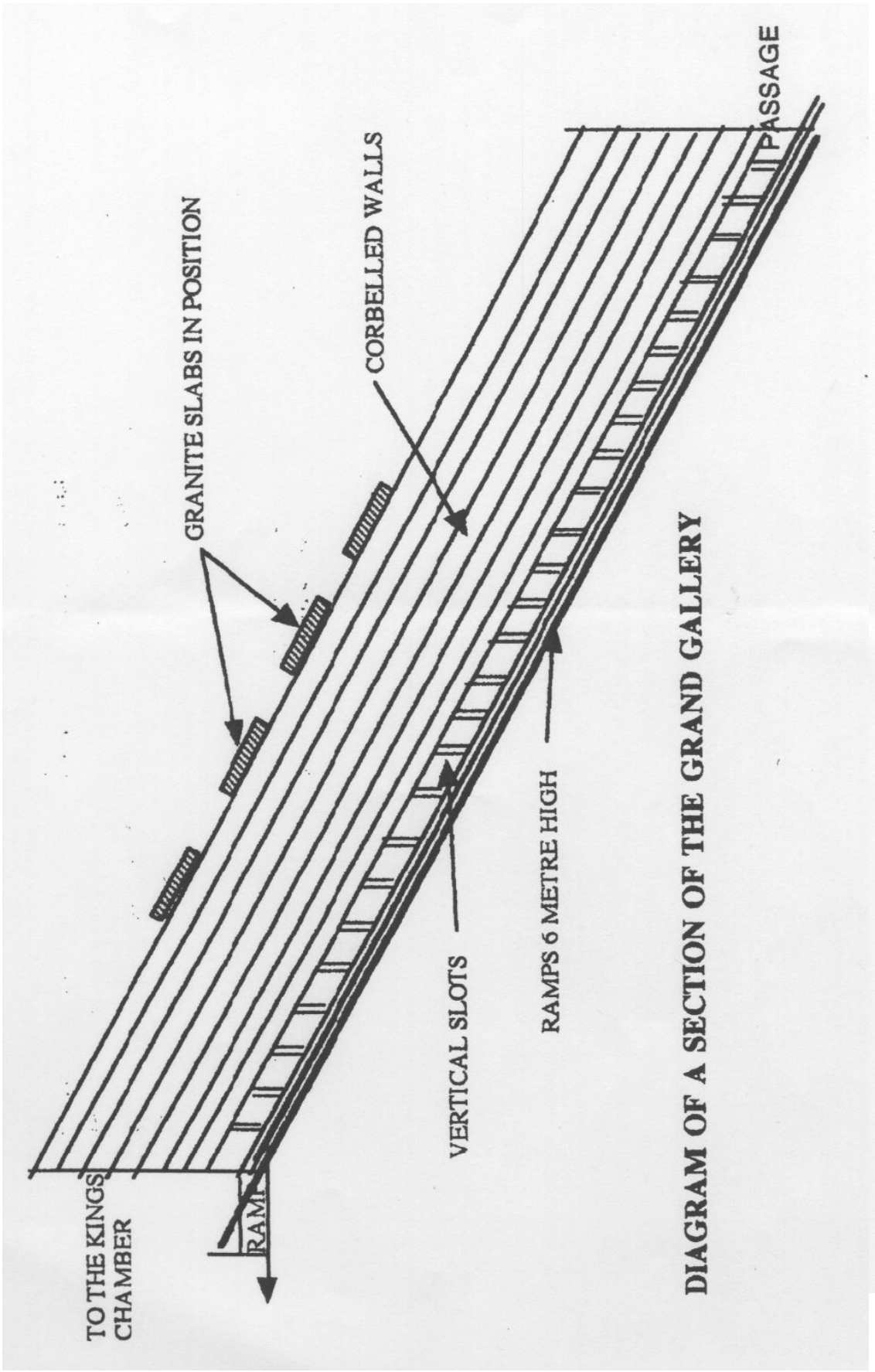
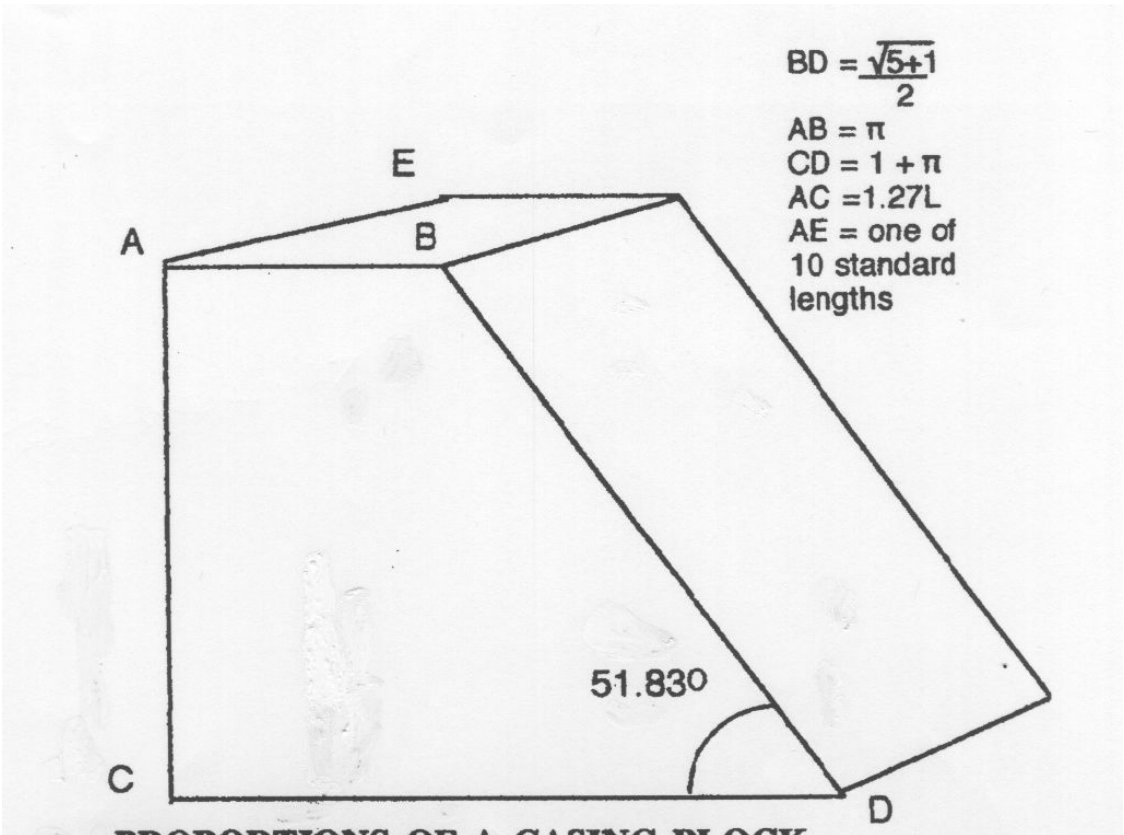
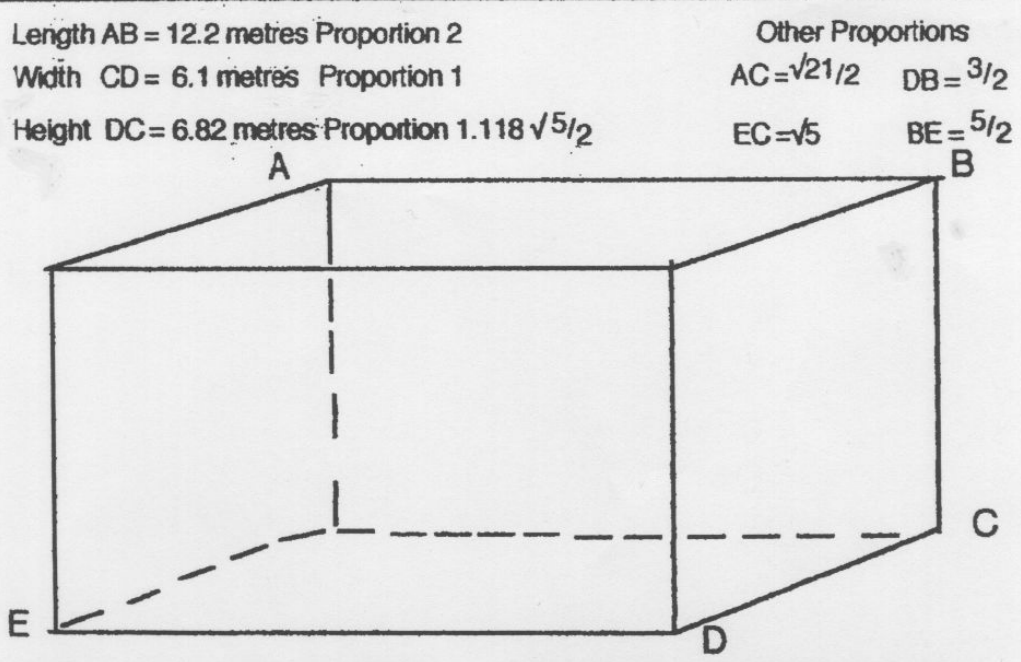
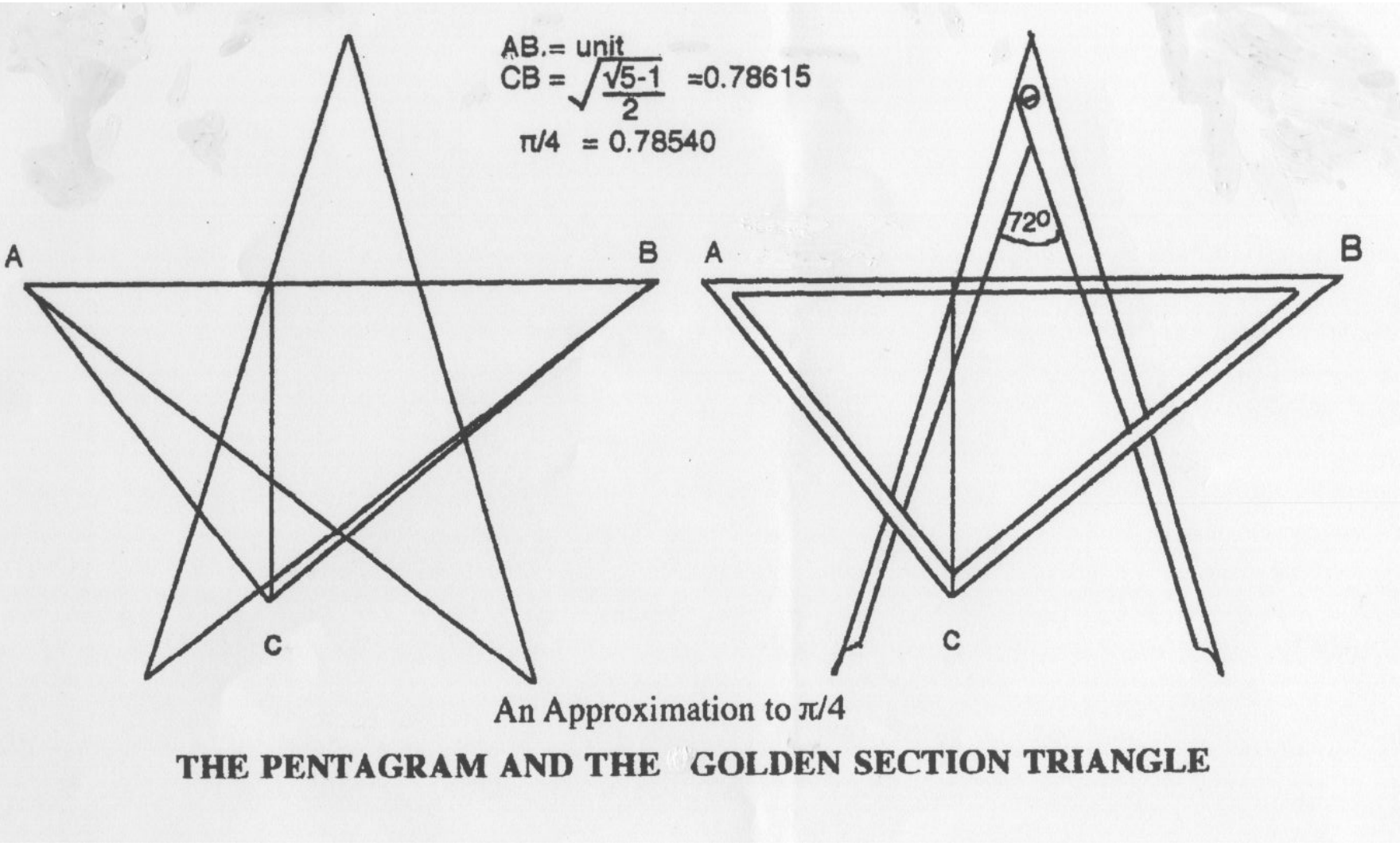




PROPORTIONS OF A CASING-BLOCK



THE KING'S CHAMBER Dimensions and Proportions



An Approximation to π/4

THE PENTAGRAM AND THE GOLDEN SECTION TRIANGLE