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The Gnomon

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No. I

THE GNOMON

as a possible link between (a) one type of Mesopotamian *Ziggurat* and
(b) the Magic Square Numbers on which Jabirian Alchemy was based.

BY H. E. STAPLETON¹

SAVE, possibly, in the case of mathematicians, human thought is very largely controlled by environment; and it was perhaps due to the fact that a previous paper² had to be finished in the unfamiliar surroundings of a nursing home that the writer failed to observe (or mention) one noteworthy consequence from the historical point of view of establishing the identity between the basic structure of certain Magic Squares (with which the paper was largely concerned) and that of the Mesopotamian *Ziggurat* at Borsippa which was reconstructed under the order of Nebuchadrezzar in the first quarter of the 6th century B.C. This omission will now be rectified.

¹ The following pages represent the introductory section of a paper on Pythagoreanism that was read at the VIIth International Congress of the History of the Sciences, held at Jerusalem in August 1953.

² "Probable sources of the Numbers on which Jabirian Alchemy was based." (*Archives Internat. d'Histoire des Sciences*, Jan., Mar. 1953, No. 22, pp. 41-59.)

The original objective of the paper in question was to account for the curious series of numbers, 28, 17, 8, 5, 3 and 1 out of which the writers of the Jabirian alchemical *Corpus*³ believed the Universe, and all it contained, to be built up.

Having noticed that the simplest 9-celled Magic Square figures more than once in the treatises of this *Corpus*, and realizing that the philosophy on which such a Number Theory was based was essentially Pythagorean in origin, it was decided to see what would be the result of subjecting this Square to dissection by a Pythagorean *Gnomon*, i.e. the numbered areas within thick lines as shown in Fig. 1. It then became obvious that the "alchemical" numbers in question were all to be found in this Magic Square. The total of the four numbers within the Gnomon is 28: the numbers in the remaining four cells of the Square are the actual series 8, 5, 3 and 1: while, finally, the total of this last series is 17. Thus, the whole series of "alchemical" numbers was intimately related to this—the First—Magic Square, and might, indeed, have originated from it.

A further method of analysing the "figure content" of the same Magic Square is to state this in terms of the Central number: and the resultant graph is that shown in Fig. 1(a).

If the same method of analysis of the numbers assigned to the constituent cells be successively applied to each of the higher Magic Squares with an odd number of cells, an extra "platform" will appear in each of the resultant graphs, until, finally, in the case of the Magic Square with 81 cells (Fig. 2), the resultant graph with its corresponding numerical (or area⁴) totals is that shown in Fig. 2(a).

Beginning with the first Magic Square—the formula of whose single "platform" is X (the central number) $\times 3^2$, the additional "platforms" of the subsequent Squares with an odd number of cells have totals respectively of $X \times 5^2$, $X \times 7^2$ and $X \times 9^2$. In other words, each total is a function of the total number of cells in the side of each Square.

The graph shown in Fig. 2(a) so closely resembled in plan the ordinary representation of a Mesopotamian *Ziggurat* that it was decided to look up the

³ Compiled in Arabic about A.D. 900.

⁴ In case any reader queries these references to areas, it may be recalled that in ancient China the ancestral square *Ming-Tang* temple had 9 rooms to which, in the same order, the numbers of the first Magic Square are assigned. Prof. H. H. Dubs of Oxford, when commenting on the previous paper, also noted that not only did the ancient Chinese place their Royal (later Imperial) Domain at the centre of a 9-squared division of the country, but the Chinese philosopher Dzou Yen (IVth cent. B.C.) enlarged this scheme by saying (a) that China was the south-eastern square in a 9-square continent, and (b) that the world was composed of 9 continents arranged on a 9-square basis. No numbers, however, appear then to have been connected with this arrangement.

From Fig. 2(a) it will also be evident that whatever the significance of the Central number may be, this variety of Magic Square can be represented by a ground plan that depends, not only on this central number, but also on the *square of the number of cells on any one side* of the individual square that is being considered.

4	9	2
3	5	7
8	1	6

Fig. 1. Magic Square assigned to Saturn and Lead.

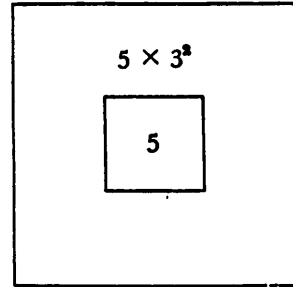


Fig. 1(a).

5	54	13	62	21	70	29	78	37
46	14	63	22	71	30	79	38	6
15	55	23	72	31	80	39	7	47
56	24	64	32	81	40	8	48	16
25	65	33	73	41	9	49	17	57
66	34	74	42	1	50	18	58	26
35	75	43	2	51	10	59	27	67
76	44	3	52	11	60	19	68	36
45	4	53	12	61	20	69	28	77

Fig. 2. Magic Square assigned to the Moon and Silver.

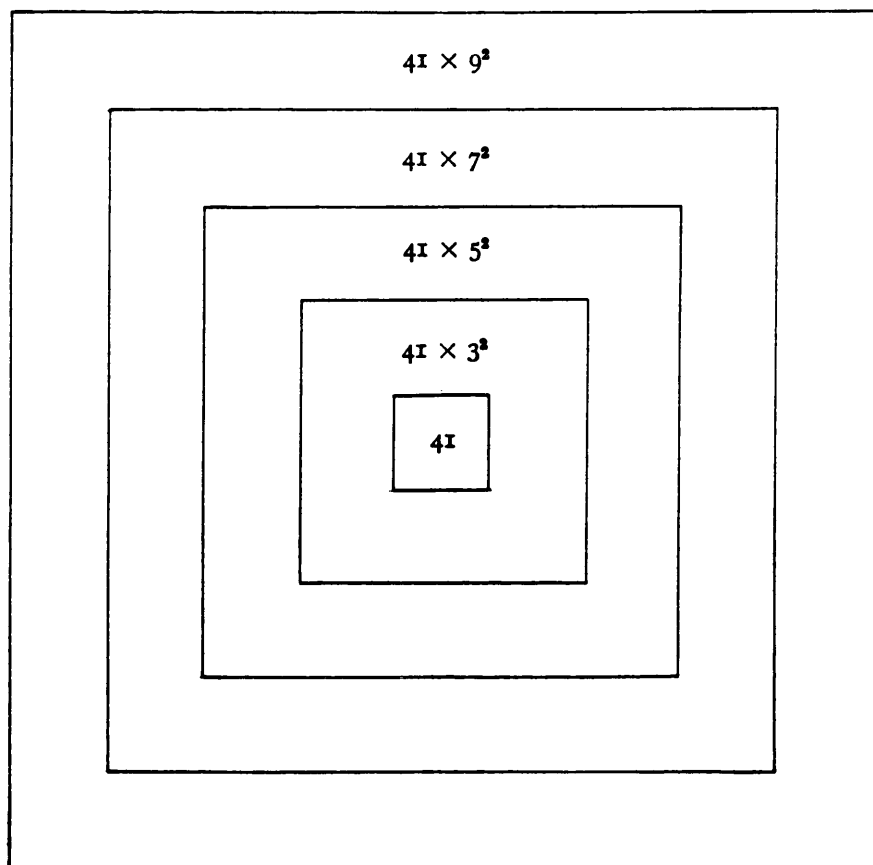


Fig. 2(a).

recorded measurements of these ancient buildings in order to ascertain whether any similar numerical relationship could be detected in the case of the platforms of a square *Ziggurat*. The one finally chosen was that excavated by Sir Henry Rawlinson about a century ago at Borsippa, N.W. of Babylon, and the measurement of the 4 surviving platforms that could be traced by him with any certainty were found to be as follows:—

D	Each side 146 feet
C	" " 188 "
B	" " 230 "
and A (the lowest platform)	" " 272 "

Inspection of these figures quickly showed that they bore exactly the same relationship of odd numbers to one another as had already been found to exist

between the "platforms" of Magic Squares: but in this case real platforms were being studied and not hypothetical ones. The respective areas of the 4 platforms A B C D of the Borsippa *Ziggurat* are in the ratio of 13:11:9:7; and if Sir Henry was correct in believing that the ancient name of the *Ziggurat E-ur-imin-an-ki* (Temple of the Seven Rulers of the Heavens and the Earth) showed that this *Ziggurat* originally possessed 7 platforms—dedicated respectively to the then recognized seven Planets—and if the remaining 3 platforms could have been measured, their areas would almost certainly have been found to be in the continued descending ratio of odd numbers, viz.: 5, 3 and 1.

We are now therefore in a position for the first time to state what was the architectural rhythm of at least one type of Babylonian *Ziggurat*, viz.: that it consisted of superimposed cubes⁵ (of sun-dried or burnt brick), the areas of any face of each cube being in proportion to the series of odd numbers 1, 3, 5, 7.

⁵ Like the Chinese, the Babylonians believed that the world was square (*vide* references to its Four Quarters): and the suggested cubic structure of the Borsippa *Ziggurat* seems probable in view of the original cubic shape of the Ka'aba at Mecca, and of Solomon's Holy of Holies on Mount Moriah. As H. Lewy has shown in her 1950 paper (*Hrozný Festschrift*), both these temples began by being dedicated to Salim, the planet Saturn.

If, moreover, there happened to survive in the Greece of 460 B.C. any belief that these Temple Cubes represented either the Universe or the Earth, this may have played some part in the assignment by Plato of the form of a cube to the element Earth. That Harmony was believed by the Pythagoreans to be symbolized by the Cube is suggested by the story (quoted by Heath, *Manual of Greek Mathematics*, p. 51) that "Philolaus is said to have called the cube a 'geometrical harmony' because it has 12 edges, 8 angles and 6 faces, and 8 is, in harmonics, the mean between 12 and 6".

The origin of the Pythagorean belief that "Harmony is the Key of the World" can be gathered from what is noted by Nicomachus (the mathematician of Gerasa in Judaea who flourished c. A.D. 100) that the "special 'most perfect proportion' consisting of four terms and called 'musical'—was discovered by the Babylonians and first introduced into Greece by Pythagoras. The proportion (used by various early Pythagoreans and, finally, by Plato in his *Timaeus*) is—

$$a : \frac{a+b}{2} = \frac{2ab}{a+b} : b$$

a particular case being 12:9=8:6. The two middle terms are the arithmetic and harmonic means between the extremes" (Heath, *idem*, p. 52).

If we consider the wealth of musical instruments that were in use in ancient Sumeria and the discussion by Woolley (on pp. 257-8 of Vol. II—*Royal Cemetery Texts*—of his *Ur Excavations*) of the possible ultimate derivation of Music from a study of the various sounds emitted by certain familiar animals, such as the bull, the cow, the calf and the stag, it is difficult not to agree with Woolley that there is a 'considerable possibility that the Sumerian musicians possessed a knowledge of harmony very surprising at so early a date (2700 B.C.)'. May not the Greek modes have a parallel if not a precedent in Sumer?"

Woolley may, indeed, have been too cautious in the last-quoted sentence: for there can now be little doubt that Pythagoras' ideas on Harmony and its connected theory of Mathematics—from which (through his greatest disciple Plato) all our present knowledge of the Universe stems—were ultimately derived from Mesopotamia.

9, 11 and 13. For stability of the resulting tower, these masonry cubes were sunk into one another: and as A. Parrot has shown in the last chapter of his recent book (*Ziggurats et Tour de Babel*), the main object of the tower was to provide a means whereby the local deity could descend from Heaven at times of festivals to receive, in the temple at the base of the tower, the offerings of the assembled worshippers. Stairways were often provided between the different platforms (or even, as at Ur and elsewhere, there was a ramp from the ground level up to the 1st or 2nd platform). In other cases, the path to the summit of the *Ziggurat* may have run spirally round the tower from platform to platform.

Two possible explanations may be offered of why the platform areas were constructed in the ratio of odd numbers.

The first arises from the fact (that must have been noticed in early Babylonia) that if any series of consecutive odd numbers beginning with 1 are added, the result is a square number. This would suggest the association in a *Ziggurat* of square areas with odd numbers.

Secondly, the sum of the series of odd numbers 1, 3, 5 . . . 13 is 49, which is the *Square* of the sacred number 7. If, moreover, the *Ziggurat* had actually 7 platforms, the sum of the numbers 1, 2, 3 . . . 7 is 28, which happens to be both 4 times 7, and also the second Perfect Number.

In the Borsippa *Ziggurat* the front of each square platform was set back 30 ft. from the front of the one below it (*vide* the copy of Rawlinson's Elevation that is to be found on p. 61 of Parrot's book), but, apart from this, the ground plan follows mathematically the model of Fig. 2 (a) *supra*. The only need is to substitute 1 for 41 in the top (central) platform, and increase the number of platforms from 5 to 7. The areas of the remaining 6 (below the top one) will then be 1×3^2 , 1×5^2 , 1×7^2 , 1×9^2 , 1×11^2 and finally, for the ground platform, 1×13^2 .

What I did not think of doing before completing the previous paper was to draw a quadrant plan of the *Ziggurat* in the mathematical (i.e. *Gnomonic*) form adopted by Pythagoras, the Greek philosopher (of c. 572–500 B.C.), and his followers. If I had done so, I would then have been forced to consider the historical implications of Fig. 3.

It is not known when exactly Nebuchadrezzar (604–561 B.C.) carried out the reconstruction of the Borsippa *Ziggurat*, but unless this was not done until the last few years of his reign (which is improbable), it is obvious that what Pythagoras and his followers called *Gnomonic* (or odd) numbers were being used as the fundamental architectural ground plan of this Babylonian *ziggurat* before Pythagoras was even born. Pythagoras would therefore appear to have derived his ideas on *Gnomonic* figures and numbers from previously existing Babylonian architectural practice and mathematical knowledge.

Corroboration of this deduction is to be found in the statement of the 5th century B.C. historian Herodotus (Book II, end of para. 109: G. Rawlinson's

translation) that "the Sundial, the *Gnomon*, and the division of the day into 12 parts were received by the Greeks from the Babylonians": and it is quite easy to understand how the idea of the *Gnomon* arose in Mesopotamia. The floors of the temples (and, later, of palaces and even the better class houses) were paved with square tiles: and a people who—as we now know from the pioneering work of Neugebauer, Sachs and Bruins on cuneiform mathematical tablets—were the first to study mathematics from the purely theoretical point of view, could not have failed to notice that in every square group of 4 tiles, one tile

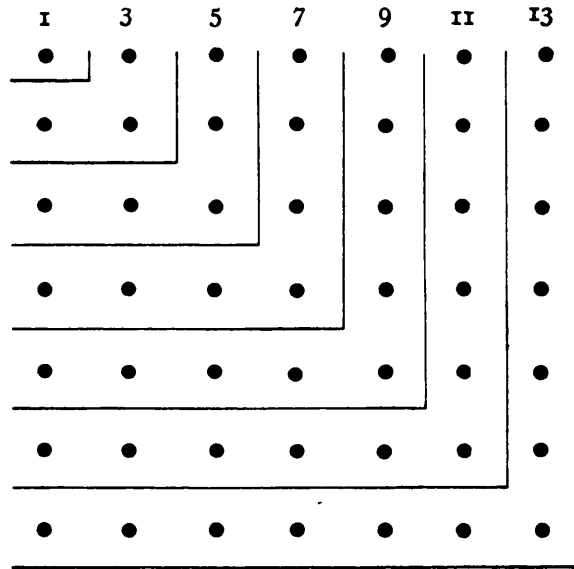


Fig. 3.

was partially enclosed by the other 3: in every square group of 9 the former square of 4 was partially enclosed by the remaining 5, and so on. The resultant rectangular figure, resembling in shape a Carpenter's Square, was given in Greek the name *Gnomon*. Similarly, the odd totals 3, 5, etc. of the tiles needed to complete these new square groups—with the addition of the unit number—were called the *Gnomonic Numbers*. Other meanings assigned to this word *Gnomon* in Liddell and Scott's lexicon are Judge or Interpreter: Guardian or Inspector of the sacred Olive at Athens: and the Index of the Sundial. Finally, according to Heath (*Manual*, p. 45), *Gnomon* connoted perpendicularity.

It is doubtful, however, whether sufficient consideration has been previously given to the real implications of this word. It is derived from the same root as the Greek *gignoskein* to know: but what *knowledge* was it supposed to impart? Would the upright stick whose shadow marked on the surface of the sundial

the passing hours have been assigned a name that almost suggests that the stick—with the aid of the sun's rays—had been changed into Ea—the third of the Babylonian Supreme Triad, Master of Wisdom and of the knowledge of the Magic Name⁶—or into Hermes, the impartor to the Greeks of the knowledge of Time?

That the original form of the sundial *Gnomon* was *not a straight rod* but a succession of *steps* will be evident from the following quotation from Note A, p. 498, Chapter XXII, of Layard's *Nineveh and Babylon*:—

"Since writing the above [viz.: that the brickwork still visible in the lower part of the Birs Nimroud mound as well as in the upper, shows the sides of several distinct stages or terraces], I have found in a treatise by M. von Gumpach (*Die Zeitrechnung der Babylonier und Assyrier*, Heidelberg, 1852, p. 25), some remarks upon the sundial mentioned in 2 Kings xx. 8–11 and Isaiah xxxviii. 8. The author conjectures that it may have been presented to Ahaz by Tiglath Pileser, and he restores it very nearly in the shape I have suggested as having been that of the edifices of which the Birs Nimroud and other great ruins in Mesopotamia are the remains, viz.: a series of steps or terraces, on which an upright pole cast its shadow. He observes that the hours were marked by the coincidence of the shadow of the *gnomon* with the edge of the steps (degrees). (See also his *Dissertation on the Old Testament*, Heidelberg, 1852, p. 181.)"

The passage in Isaiah to which attention is drawn runs as follows in the Revised Version, where the Prophet is repeating to Hezekiah the message of God that, in response to the King's prayer, his life would be spared. "And this shall be the sign unto thee from the Lord that the Lord will do the thing that He hath spoken [that Hezekiah would live for 15 more years]. Behold I will cause the shadow on the steps which is gone down on the dial (Hebrew, *steps*) of Ahaz with the sun to return backward ten steps. So the sun returned ten steps on the dial, whereon it was gone down"⁷.

The *Gnomon*—both as the index of a Sundial, as well as in its later form of a Carpenter's Square—would therefore appear to have been intended to symbolize a Babylonian *Ziggurat*. If so, what further inference would seem probable?

In view of the fact that the Gnomonic Numbers have been shown to represent the architectural rhythm of the Borsippa *Ziggurat*, it may, to begin with, be suggested that the *Gnomon* was originally intended as a *cryptic* representation

⁶ Cf. J. Marquès-Riviére's *Amulettes, Talismans et Pantacles*, pp. 83 and 86, Payot, Paris, 1950.

⁷ Hezekiah was the son of Ahaz, King of Judah, who had appealed to Tiglath Pileser IV of Assyria (745–727 B.C.) for help in 734 B.C. against Pekah of Israel and Rezin of Damascus. This led to Pekah being deposed and Damascus becoming an Assyrian province (see C. H. W. John's *Ancient Assyria*, p. 109). Ahaz was completely subservient to the Assyrian monarch. He removed silver and gold from the Temple in Jerusalem to present to Tiglath, and, in addition to making various changes in the Temple with the idea of pleasing his Assyrian overlord in case he happened to pay a return visit to Jerusalem, made Urijah, the High Priest, build in the Temple a pagan altar, modelled on one Ahaz had seen in Damascus (vide 2 Kings xvi. 8–18).

of such a *ziggurat*, whereby followers of Assyrian⁸ or Babylonian religion, both in Mesopotamia and elsewhere, could still imagine what the building looked like and what were the simple mathematical elements in its structure.

A similar—but even more cogent—example of cryptic symbolism is the 25-lettered quasi-Magic Square of the late 2nd or 3rd century A.D. Christians that has been discussed by J. Carcopino in the August 1948 number (pp. 16–59) of *Museum Helveticum*—*vide* Fig. 4. No one but an initiated Christian could possibly imagine that the letters in this Square were capable of being mentally transposed into a reminder of the crucifixion of Christ, or of their being read as a double reminder of the first two words “Pater Noster” of the Lord’s Prayer—*vide* Fig. 4(a).

R	O	T	A	S
O	P	E	R	A
T	E	N	E	T
A	R	E	P	O
S	A	T	O	R

Fig. 4.

A
 —
 P
 —
 A
 —
 T
 —
 E
 —
 R
 —
 A/P A T E R N O S T E R/O
 —
 O
 —
 S
 —
 T
 —
 E
 —
 R
 —
 O

Fig. 4(a).

Moreover, as, in both cases, the initial P was prefixed by A (for Alpha) and each of the final Rs of the *Noster* had a suffix O (for Omega), this double A—O (by their reference to the phrase in Chap. I, v. 8 of “The Revelation”, “I am the Alpha and the Omega, which is, and which was, and which is to come”)—would again recall to the Christian interpreters of the 25 letters of the Square, the name of Christ, their Redeemer.

In conclusion, one further inference as regards the possible continued history of the *Gnomon* seems worth mentioning. If the 7 platforms of these square *ziggurats* were intended to represent the spheres in which the 7 Assyrian and Babylonian planets moved, the *Gnomon* may also have been regarded as symbolizing that portion of the Universe by whose influence man has long supposed himself to be chiefly affected. If so, this might explain why the *Gnomon* is still found in symbolic use as one of the chief emblems of Free Masonry.

⁸ The *ziggurat* on which Hezekiah’s sundial was modelled must have been Assyrian—a prototype of the one at Khorsabad (Dur Sharrukin, near Nineveh), built by Sargon II (722–705 B.C.), the next Assyrian king but one to Tiglath Pileser IV. As the plan of Sargon’s square *ziggurat* that is to be found in V. Place’s *Ninive et l’Assyrie*, shows, its platform areas bore the same numerical relationship to one another as those of Nebuchadrezzar’s much later *ziggurat* at Borsippa.