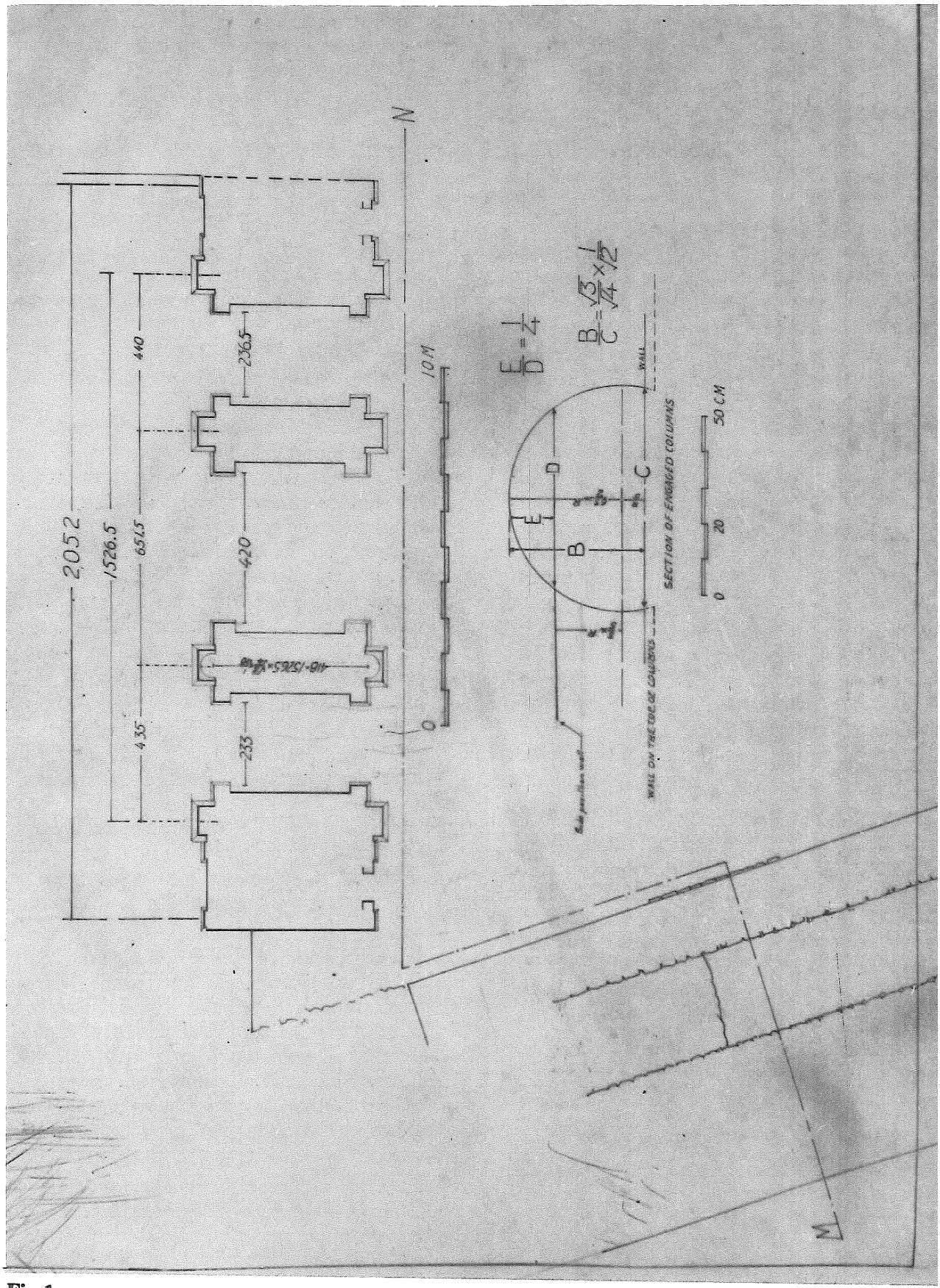
N
2052
1526.5
651.5
440
435
420
236.5
233
10 M
0
E = 1/4
B/C = √3/4 × 1/2
WALL
B
C
D
E
SECTION OF ENGAGED COLUMNS
WALL ON THE SIDE OF COLUMNS
0
20
50 C.M
M

Fig 1

Restoration in Jerash
(With observations about the related Monuments)

by
H. Kalayan

I **The South Gate:** The five year Touristic Project Plan, includes among others the restoration of the south gate of the old city, to serve as main entrance gate for all visitors, with its visitors centre and restaurant facilities immediately to the south of the gate. Pl LXXXVII, I

The plan and the parts still in place of the south gate suggest that its elevation was similar to the triumphal arch of Hadrian, as already described in detail by Detweiler[1]. The south gate is similar in conception, but not in dimension to the triumphal arch in front of it.

The elevation of the south gate represents a problem, the engaged columns have no entasis, nor a reduction of diameter, to determine graphically or by calculation the probable height of the column, although the wall of the engaged column inclines backward at the top of the column about 2 cms, but keeps the diameter of the column the same. This same observation applies to the triumphal arch; (I could not measure the exact backward inclination of the wall, because there are no drums with part of the engaged wall on it).

Help of Arithmetic

Our previous experience had shown that the section of the engaged columns have the same symmetry with ratio or proportion as the elevations of doors and columns connected to the design.

The engaged column sections are designed at the base 1/5 radius more than semicircle. Thus the ratio of the cord C of the section, to its bisector B limited by the circumference:

$$\frac{B}{C} = \frac{\sqrt{6}}{2\sqrt{24}} = \frac{\sqrt{3}}{\sqrt{4}} \times \frac{1}{\sqrt{2}}$$

Thus the height of the doorway H, to its width W, must have the same ratio or proportion; (see plan of south gate fig 1)

$$\frac{W}{H} = \frac{\sqrt{3}}{\sqrt{4}} \times \frac{1}{\sqrt{2}}$$

The exactitude of this is verified by the width and height of the capital still in place on the western side entrace doorway.

$$\frac{W}{H} = \frac{236.5 \text{ cm}}{386 \text{ cm}} = \frac{\sqrt{3}}{\sqrt{4}} \times \frac{1}{\sqrt{2}}$$

236.5 has to be 236.37 taking 386 as correct. Hence the height of the columns must be in inverse ratio. The axial distances measured from west to east;

440+561.5 435=1526.5 cms.

Hence the height of the columns with the base and the capital Ch.

$$Ch = 1526.5 \times \frac{\sqrt{3}}{\sqrt{4}} \times \frac{1}{\sqrt{2}} = 934.8 \text{ cm.}$$

Since the layers of the courses are practically the same, i.e. between 58-59 cm., then there should be 16 courses with average height of 58.4 cm. This does not apply to the doorways. This can not be the foot as well. The number 934.8 is commensurable with 1526.5 in square only, so the former is called a MEDIAL line. (Book X proposition 21, Euclid (2)). The foot can be the axial distances 1526.5 which divided by 52 gives 29.36 and such a distance is marked on a level line on the south podium of the temple of Artemis.

If we consider the axial distribution of distances

$$\frac{440}{526.5} = \frac{1}{3} \times \frac{\sqrt{3}}{\sqrt{4}}$$ 440 should be 440.6 cm

The same symmetry expression $\frac{\sqrt{3}}{\sqrt{4}}$ as in the $\frac{\sqrt{3}}{\sqrt{4}} \times \frac{1}{\sqrt{2}}$. The expression $\frac{\sqrt{3}}{\sqrt{4}}$ is called the symmetry-commensurability- of the sides of the rectangle formed by base line axial distances,and the height of the column. It is a geometrical expression, and Vitrivius (Book I c.I, 4 and Book III c.I, 1) states, "The planning of temples depends upon symmetry; the difficult problems of symmetry are solved by geometrical rules and methods, and the method of this architects must deligently apprehend" (The Loeb Classical Library). In this case, the south gate symmetry, or commensurability, is as the long side of a 60° right angle triangle to its hypothenuse.

The symmetry in this case, as the square areas formed by the two lines; this kind of symmetry is defined by Euclid in Book X def. 2:[2]

"Straight lines are commensurable in

square (symmetrical in square) when the squares on them are measured by the same area". Thus the squares formed by the lines $\sqrt{3}$ and $\sqrt{4}$ will have the areas 3 and 4 units square and there difference is one unit square which measures the 3 unit square.

According Plato "Commensurability in square" or "symmetrical in square" nomination was due to Theaetetus, (148 B) where Plato states on behalf of Theaetetus, such numbers, as $\sqrt{3}, \sqrt{4}$, "we called roots as not being commensurable (symmetrical) with the other in length, but only in plane areas to which the squares on them are equal".

The expression "symmetrical in square" may belong to Theaetetus, while its use is common in Egyptian monuments. A nice example, (that even the drawings were made on papyrus with proper grid), is a drawing on papyrus belonging to 18th dynasty, published in Architecture of Kalabsha, the grid of papyrus is not a square but the sides are

$\frac{\sqrt{15}}{\sqrt{16}}$ horizontal to vertical as I could measure it on the plate.

Again the grid on a stone published in Kalabsha, measuring 42 mm by 42 mm, ten of them 42cm; $\frac{42}{\sqrt{2}}$ 29.698 cm, which corresponds to the dimension of Roman foot. So the square of the foot was used in Kalabsha.

In an altar of the Egyptian Middle Empire displayed in the Museum of Brussels (Ciquantenaire), the dimensions are in the ratio of $\frac{\sqrt{4}}{\sqrt{3}} \times \frac{1}{2}$

The formula for any two numbers, A and B, which are symmetrical and in harmony is given by Theon of Smyrna (section XXXI):

$A^2 - 2B^2 = \pm 1$

In this case again the symmetry is in square and, A and B, have the ratio.

$$\frac{B}{A} = \frac{\sqrt{N+1}}{\sqrt{N}} \times \frac{1}{\sqrt{2}}$$

Thus $N \pm 1$ and N is the commensurability in square while $\frac{1}{\sqrt{2}}$ is the proportion.

Plato refers to the same formula in the numerical form (Republic 546 C) $\frac{\sqrt{50}}{\sqrt{40}} \times \frac{1}{\sqrt{2}}$ stating that the rational diameter of 5 is 7.

The above formula governs the triumphal arch of Hadrian, and is confirmed by the height of the three doors where $\frac{W}{H} = \frac{5}{7}$

Accordingly the height of the columns must be with the following axial distances

$581.5 + 967 + 581.5 = 2129.5$

$2129.5 \times 5/7 = 1521$ cm

Detweiler has designed with 13 m. (on scale), one error of design is the height of the niches on top of side entrances, according evidences on ground it is two courses higher. In this case the inscriptian of Hadrian can be placed on top of central arch way, below the crowning entablature.

The same formula of design for the triumphal arch is verified by the section of engaged columns, the section is around 1/3 radius away from the centre, actually it must be 0.342 radius. It is difficult to measure the difference between 1/3 and 0.342, unless one can find original design lines on the section, specially on lower drums.

According to authors of classical period the symmetry between two lines must differ by one unit. "whatever the unit may be", as in the case of 3 and 4, so that there may be harmony in design. The famous mathematician of Gerasa, Nicomachus, expresses the rule for harmony; "Everything that is harmoniously constituted is knit together out of opposites and, of course, out of real things; for neither can non-existent things be set in harmony, nor can things that exist, but are like one another, nor yet things that are different, but have no relation one to another. It remains, accordingly, that those things out of which a harmony is made are both real, different, and things with same relation to one another."

"Of such things, therefore, scientific numbers consists, for the most fundamental species in it are two, embrassing the essence of quantity, different from one another and not of a wholly different genus, odd and even, and they are reciprocally woven into harmony with each other, inseperably and uniformly, by a wonderful and divine Nature....."[3]

The harmonious symmetry consists of two quantities differing by one quantity, thus one even the other odd number.

The proposition 17 of Book X of Euclid's Elements, for commensurability in square gives the same result, that is, the square on two unequal lines should differ by a unit measure symmetrical with the shorter line.

The proposition 17

"If there be two unequal straight lines, and to the greater there be applied a parallelogram equal to the fourth part of the square on the less and deficient by a square figure, and if it divide it into parts which are commensurable in length,

then the square on the greater will be greater than the square on the less by a square on a straight line commensurable with the greater." (2)

If **a** the greater line and **b** the lesser line;

$$x\,(a-x) = \frac{b^2}{4}$$

$$x = \frac{a}{2} - \frac{\sqrt{a^2-b^2}}{2}$$

the value of x to be rational a^2-b^2 should be equal to unity, what ever it may be, which will measure b^2, and hence a and b are symmetrical in square.

Already all the propositions of Book X (115 in number) are made to serve the architect, about the lines he is using if they are commensurable with each other, as the height of the columns of the south gate and the axial distances as a whole, they are not commensurable, hence he has to calculate it graphically and mark a unit of measure for laying out.

Why should there be a difference in symmetry for the same kind of construction in the same city; The triumphal arch symmetry is $\sqrt{50}/\sqrt{49}$ while that of the south gate is $\sqrt{3}/\sqrt{4}$, but their proportions are the same $1/\sqrt{2}.\ \sqrt{3}/\sqrt{4}$ represents Baalshamin(8).

Let us examine some cases to find a plausible answer: The temple of Artemis in its peristyle column,breadth from center of column to center of column B, and the lenght L:

$$\frac{B}{L} = \frac{1952}{3730} = \frac{\sqrt{12}}{\sqrt{11}} \times \frac{1}{2}$$

Artemis was a patroness of Gerasa, the same symmetry is found in Parthenon of Athena, patroness of Athens,

$$\frac{B}{L} = \frac{2876.5}{6745.5} = \frac{\sqrt{12}}{\sqrt{11}} \times \sqrt{\frac{1}{6}}$$

There are similarities in the characters and attributes of Artemis and Athena, so both have the same number of symmetry for their temples, or the above symmetry is for the patroness of the cities. The proportion depends on the planning required from the architect. In the Parthenon the need was for a long cella so the architect chose the proportion as $1/\sqrt{6}$, while in Gerassa where there was no need for a long cella, the architect has chosen ½. (4)

Another example is the Zeus temple in Jerash, $\frac{B}{L} = \frac{\sqrt{9}}{\sqrt{10}} \times \frac{1}{\sqrt{2}}$ while the temple of Jupiter in Baalbec $\left(\frac{B}{L} = \frac{\sqrt{10}}{\sqrt{9}} \times \frac{1}{2}\right)$. The former has 8 columns in front and 12 on the side, while the temple of Jupiter has 10 columns in front and 19 on the side. Both the numbers 9 and 10 are attributed to Sun and 10 to unwearied God.[5] In Jerash the architect has intended to have a larger front; around 0.67 L, while in Baalbek it is 0.53 L. But in octastyle the height of the column is $B/\sqrt{3}$, and this will be true for the temple of Zeus if $\frac{B}{L} = \frac{\sqrt{10}}{\sqrt{9}} \times \frac{1}{2}$ as calculated in Baalbek, then $B/\sqrt{3}$ is exactly the height of the column as given by Kraeling.

(Above statement of $B/\sqrt{3}$ for the height of the columns, is based on the temple of Bachus in Baalbek[6], and that of the Temple of Bel in Palmyra[7].)

The above discussion suggests that there were special numbers attached to Gods or they were their attributes, and there is a symmetry for each temple, and any common measure for B and L is not possible if the symmetry is in square; rounding of measured figures may have a common highest factor, but it must not be taken as a correct one. The Palmyrean temple of Baalshamin was published with a common measure[8], and it was $\frac{B}{L} = \frac{\sqrt{4}}{\sqrt{3}} \times \frac{1}{2}$. The Temple of Bel in the same city is published with a common measure, but $\frac{B}{L} = \frac{\sqrt{13}}{\sqrt{12}} \times \frac{1}{2}$, the same proportional number of interspacing of columns 24 to 26 on the opposite side of the entrance of the court, shows that the symmetry was 12 to 13, and the doorway of the peristyle columnade is placed with 5 intercolumnar space on one side and 7 on the other side so it is $\frac{\sqrt{50}}{\sqrt{49}} \times \frac{1}{2}$ thus it is, not an arbitrary one.[4]

The south gate elevation was designed on the above mentioned mathematical basis. The elements of previous excavations were piled inside the city (Pl) LXXXVII, about 50 m in front of the gate. The pile contained elements belonging to the eastern door leading into the lower courtyard of the temple of Zeus, two elements belonging to the main entrance from the forum in to the lower court of Zeus temple, and two corbels belonging to the same door (probable), other elements of doors with letters A and B.

The elements belonging to the south gate had enough drums to complete practically one facade, but since the excavation had dug both outside of the gate and inside, we reasoned that it must belong to both facades, and a tentative distribution was made on the sketch. (see elevation Fig. 2)

The western side gate, because its width, the extrados of the arch was entering into the

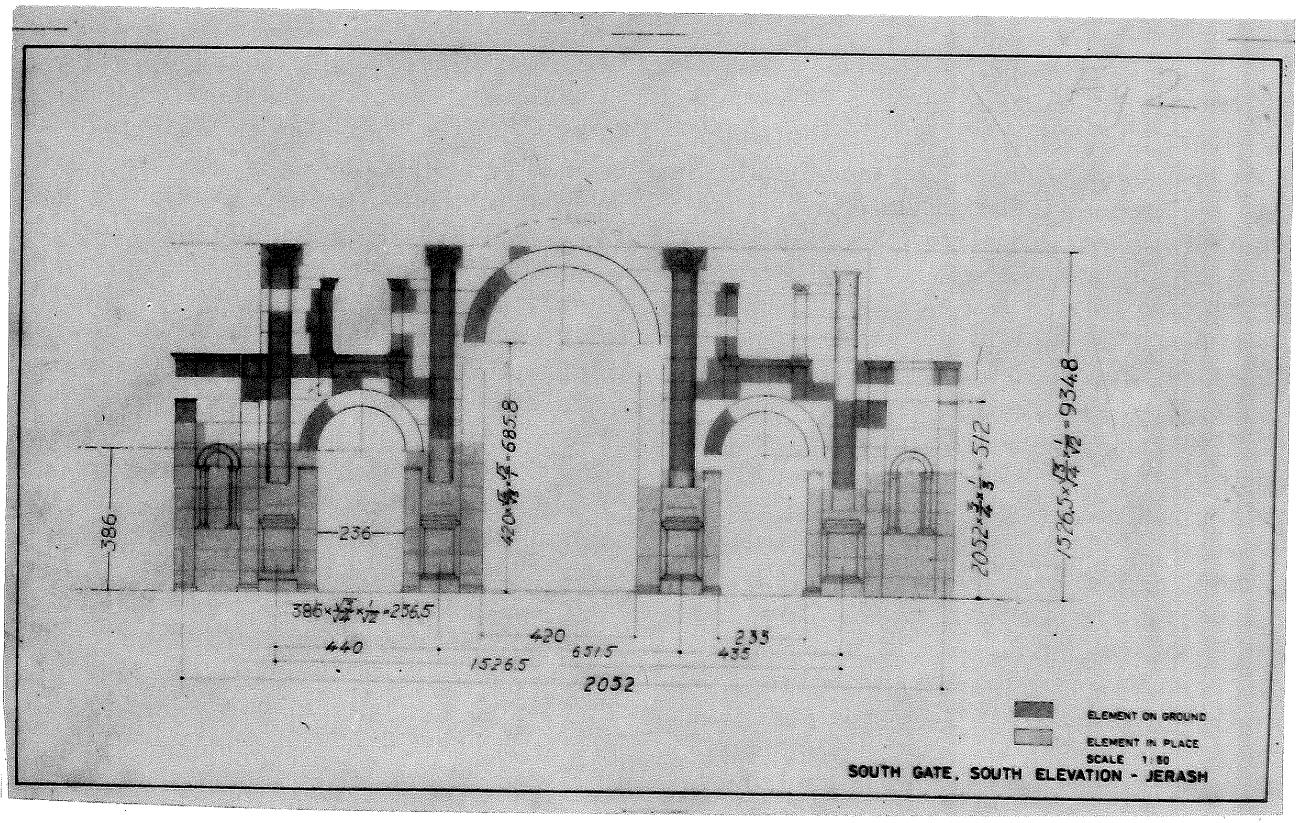

Fig 2

course with corbelling for the niches above the side doorways, an element with corbelling and with the required reduction just after corbelling was found, thus verifying the elevation. On the near side of this element a curved tracing designed the inner arch for the passage way between two sides of the door.

The elements of the niches with their capitals were there, but none of the elements of the projecting architrave on to the columns supported by the corbelling. We could not find any element of the pediment which would crown the top of the capitals. Due to the works around the new visitors' center, some excavation was done in front of the gate, which revealed parts of the western column and its capital, and a capital belonging to the pilasters of the west pavillon, and some elements of the eastern side. (Pl LXXXVIII).

The excavation conducted on the north side of the gate revealed elements still in order, fallen down probably due to an earth quake, specially the western pavilion, and part of central door pilasters and the capitals. The western pavillion had fallen on top of the fallen walls of Zeus court yard. (PI) LXXXIX,1

The facade of the Zeus temple court yard facing the forum has fallen in a row, probably from the same earth quake. (Pl) XCI, 2

The intact form of the elements of the temple of Zeus indicate that the temple had not served as a quarry to Byzantine period constructions, but this is not the case for the temple of Artemis, where so many of its architraves served as lintels to churches. One might conclude that the temple of Zeus was already in ruins when Byzantine construction was flourishing, or the Zeus area was a forbidden zone.

The entrance to the court of the Zeus temple, from the east side, has a second period sill-stone with a cross and a Greek inscription on it; this might suggest its use during the Arabic period. Thus the city wall built against the eastern temenos of Zeus temple, may be dated to a later period than the same wall in other areas. The addition of the city wall on temenos has left the door intact, and the door is not extended to the additional part of the wall.

The temenos wall is decorated with engaged columns which are quite worn out, showing a long period of exposure to weathering. Except for a few pieces of the flat arch, the other elements of the door are in place [10]. These facts may lead one to suppose that the wall along the temenos is an addition of either late Byzantine or early Arab times. This may explain why some

elements of the flat arch have found their way down to the south gate to block probably the side doors. Old photographs show that the side gates were blocked. The Central entrance has three distinct periods. During the second period the door way was reduced by additional Pilasters 79cm, on each side, with no additional sill. In the third period there were added two layers of dressed stone not fitting very well in joints; the top one is a sill in two pieces, and reveals that the closing doors were of 135 cm. and 120 cm on their outer faces, and 120 on the east side was placed about 5 cm higher than 135 cm. At the level of this later sill on the outside facade of the south gate, (at a man's height) there are Omayad period inscriptions, and it can be assumed that the last sill of the gate was of this period, and the additional pilasters of the second period were most probably of the late Byzantine period when there was a Persian menace. At the level of Omayad period entrance, inside on the west side, there are a row of sills suggesting the probability of shops bordering the central entrance in use; the ones on the east side have disapperaed, due to excavation or quarrying in the past. The south pavillon has fallen on these shop constructions, thus the west pavilion has been demolished by an earthquake of late Omayad period.

The Entrance sills of the three doors of Roman period reveal that the carriages entered only through the west side door. There are no carriage traces on the east side, and as far as I could see there are none on the central door.

A wall on the eastern side of the south gate, (due to its stepping up foundation towards the city, under well dressed courses,) suggest that there were wide steps on the eastern side to go to the constructed city level, (fig 3), and only the east side gate and the central gate were leading the pedestrians in to the city through the steps. A second wall on the east side of the above mentioned one, show that the ground was higher than the first five drums of the columns.

(Pl) LXXXIX,2. And when the doorway retaining wall for the steps were constructed they dug down into 3 layers marked by the red soil, and the lower layer contains hellenistic pottery. (see section MN fig 3)

Thus there were two level of entrances from the south gate; one from the western side door, arriving probably level with 89 meter long (without the apse)[11] subterranean vault, below the level of the forum 2.78 m. (fig 4) The vault has three entrances, two on each side of the main entrance in to the lower court of the Zeus temple, and one further to the west, (pl) XC,XC1 there is evidence, due to the wall limiting the extention of landing in front of the main entrance (pl) XCII in the court of the Zeus temple that this wall extends further to the east into the front of the door of the vault, suggesting the possibility of steps leading up in the landing fron the interior of the vault. This is not the case for the second door on the west side of the landing, and the third one is further on. Thus while passing through the west side door, with carriages, the pilgrims had to pass through the vault and climb up to the so called forum, (Fig 5) which was a sacrificial ground, with two altars.

Pl.XCII,1 One is partly restored, but of the second all elements are lost, except that it was a rectangle $\frac{405}{450} = \frac{9}{10}$ with probable steps on the west side, and there was a piped (probably) channel leading down the liquid, along the south facade, while the square restored one had it on its west side[12]. These were the main altars for sacrifice, with devotees as spectators on the seats found near the altars[13]. And further, the columns limiting this sacrificial ground called the Forum, on its western side, between the two doors of wider intercolumnal space,--six intercolumnal space from the southern one and five intercolumnal space from the northern one,--there are five intercolumnal space, with special cut made on the Ionic capitals to receive a curtain or a closure in between columns, and in the middle spacing the closure or the curtain would stop, a little higher than a man's height and, in a special cut on the column and on the bases, probably a wooden door construction was inserted, so back to these column there was an area which was concealed with an obstruction and a door way was connecting it with the altar ground. (Pl.) XCIV

Similar semicircular ground connected to a rectangle all along the length of the propylaeum of Baalbek was found in 1975, (pl.) XCV with seats along the circumference of the whole enclosure; a paved ground, with several altars in it, which is shown on the coin of Philip the Arab, with a circular line extending from one tower of propylaeum to the other. A road, from the triumphal-arch-like, northern gate of Baalbek, led towards the norhtern tower of the Prop-

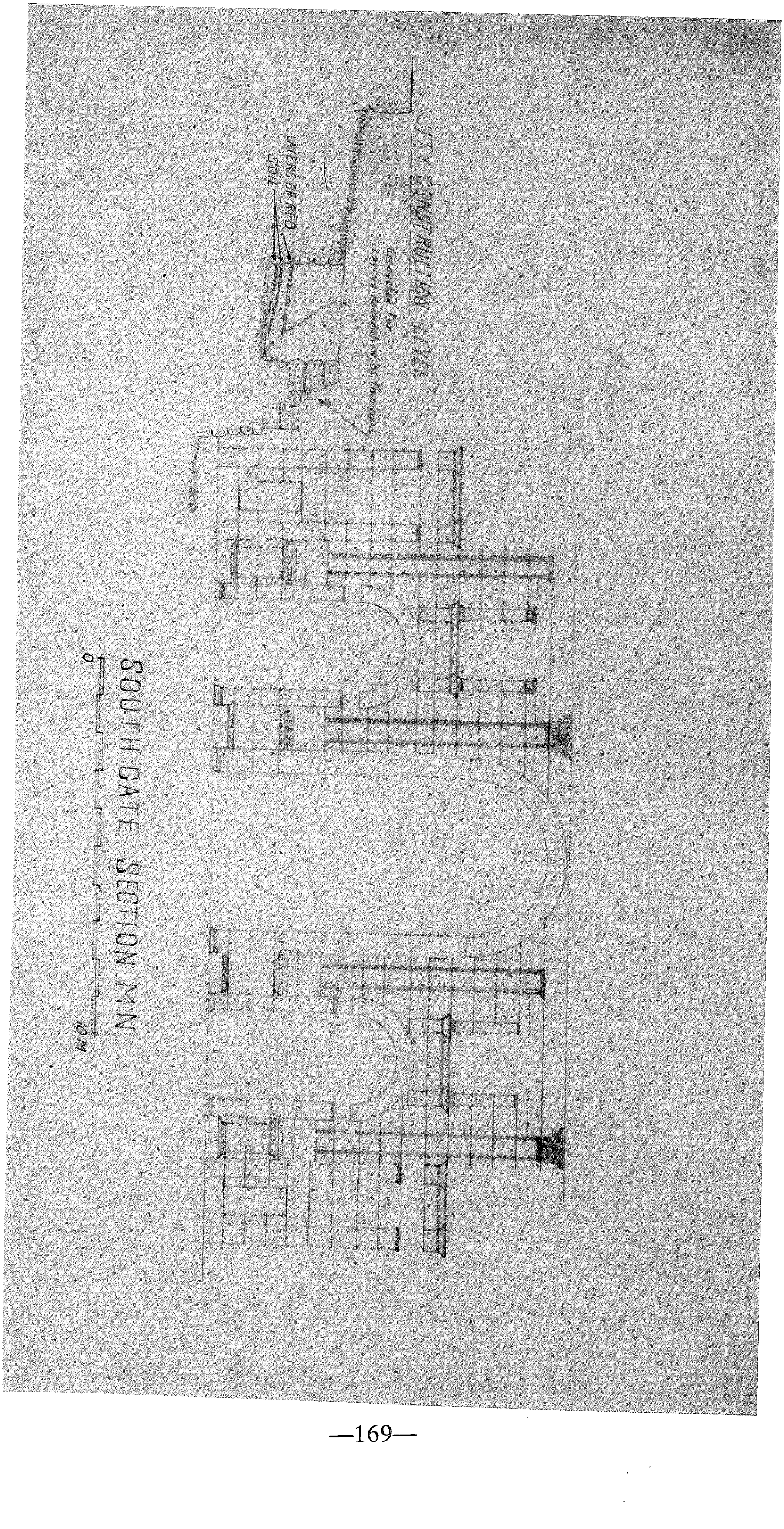
CITY CONSTRUCTION LEVEL
Excavated For Laying Foundation of This WALL
LAYERS OF RED SOIL
SOUTH GATE SECTION MN
0
10 M

Fig. 3

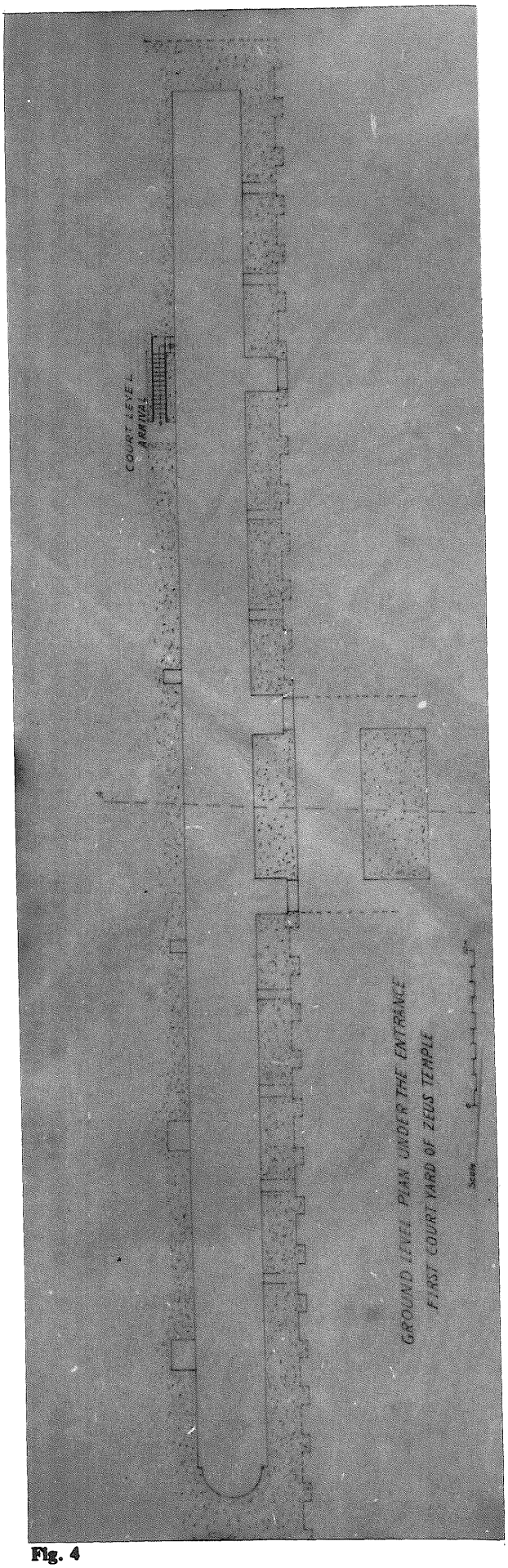

Fig. 4

ylaeum, which had two gates, one on the road side, and the other leading into the sacrificial ground, as it is in Gerasa.

The same remark can be made about the paved ground just after the triumphal arch in Petra, with two rows of seats, still existing on the left side, while those on the right side have been lost, and on the pavement there are traces of construction, probably altars, and this space would lead into the temenos of Qasr el Bint.

Notes:

1) Gerasa, City of the Decapolis, C.H. Kraeling, (1938) page 73, south gate page 149.
2) The thirteen Books of Euclid's Elements, by Sir Th. L. Heath, (1926). Cambridge.
3) Nicomachus of Gerasa, Introduction to Arithmetic, M.L.D'ooge, University of Michigan press, (1938.) Book I, ch. VI, even and odd identified with sameness and otherness. The chapter on "Philosophy of Nicomachus" mention that most of the classical writers express the same idea about Harmony.
4) Vitruvius, Book III ch. IV, 3: "The length of the work will be twice the breadth." Book IV, ch. IV. l; "The length of the temple is so arranged that the breadth is half the length."
5) Nicomachus of Gerasa, page 106-107, quotation from Theologumena Arithmeticae.
6) Bulletin du Musee de Beyrouth, T. XXIV, page 58.
7) **Le Temple de Bel, Paris (1975) Not calculated in the publication.** H. Seyrig, R. Amy, E. Will,
8) **"Le Sanctuaire de Baalshamin a Palmyre," Paul Collart, and Jacques Vicari, 1969, Institut Suisse de Rome; Geometrical solution, Annales Archeologiques Arabes Syriennes, 1972, page 157, by H. Kalayan.**
9) Le Temple de Bel....Page 119
1) Gerasa, A.H. Detweiler, page 152. "Voussoirs of the flat arch of the old south gate were found in the debris, having probably been reused in the core of the new." This refers to the flat arch voussoirs we are identifying as part of the door on the eastern temenos of Zeus temple.
11) GERASA, page 18, note 27
12) **Bulletin du Musee de Beyrouth** T. XXII page 151 "The altar had a canalisation (tubular) from the west facade leading down into two shallow successive bas-

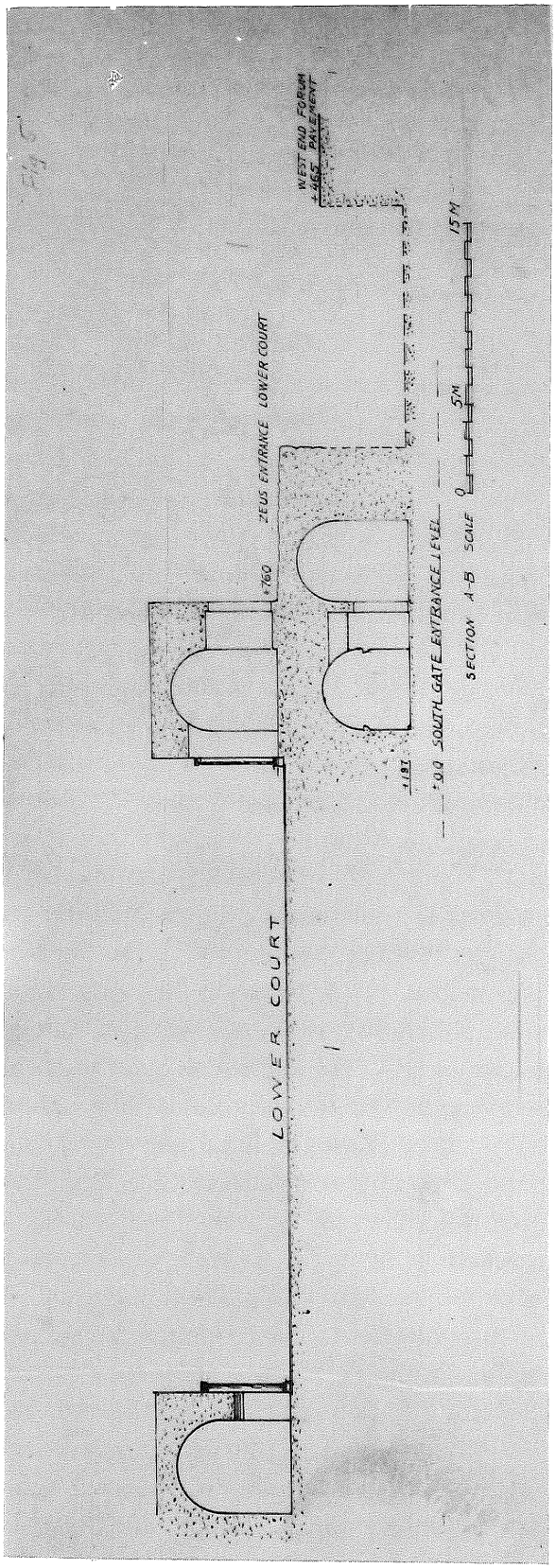

Fig. 5

sins." The remark is about the small altar at Baalbek.

In the forum the small square altar is constructed in a rectangular area of 845 by 750, $\frac{750}{840} = \frac{9}{10}$ showing that with symmetry it has the same concept as the temple of Zeus, although the altar is a square. The altar is later addition inserted into the rectangle, the altar must have had a direct dedicating in the name of Zeus, to be square, the symbol of sameness. Another rectangular area situated to the east of the square altar has the dimensions of 335 by 500 $\frac{335}{500} = \frac{\sqrt{9}}{\sqrt{10}} \times \frac{1}{2}$ This same fact is true for Baalbek all constructions in the rectangular courtyard have a symmetry of 9/10 the publication of petit Autel by P. Collart and P. Coupel is based on a distorted dimensions so it is all unfounded although the plans of the first period, second course on are my plans and they have the correct dimensions. The $\frac{B}{L} = \frac{9}{\sqrt{10}}$ and the height of the altar $H\sqrt{BxL}$. "Le Petit Autel" P. Collart P. Coupel PARIS 1977.

13) L.Harding"Recent work on the Jerash Forum". P.E.Q(1949)p.12-20