THE TREATMENT OF RE-ENTRANT ANGLES*

(PLATES 27-28(a))

The triglyph problem which arose at the corners of a Doric building, and was held by Vitruvius1 to be responsible for the disuse of the Doric order in Roman times, has for many years been discussed by archaeologists. The best short explanation of the difficulties involved is probably that by Robertson.2 The much more complex problems which are met at a re-entrant angle in the Doric order, have, on the other hand, received little attention, for such angles do not occur in temples, the type of building which has been studied most thoroughly. They do, however, appear fairly frequently in more utilitarian buildings such as stoas and palaistras, and various treatments of them were evolved.

If the intercolumniation at a re-entrant angle is normal, the thickness of the returning frieze occupies the space which would otherwise be taken by the triglyph over the corner column and by part of the metope next to it (FIG. 1A). The problem is to evolve a satisfactory treatment of the frieze. The possible solutions are numerous and entail changes in the intercolumniation, the frieze, and the cornice.

It will simplify discussion if we examine these possibilities in isolation from the actual examples. They can be divided most conveniently into two classes: in the first class two metopes, and in the second, two half triglyphs, meet at the re-entrant angle. Among the first group the simplest treatment is to leave the corner intercolumniation unaltered so that two short metopes meet in the angle of the frieze. Their length will be reduced by

\[
\frac{2}{\text{thickness of architrave} - \text{width of triglyph}}
\]

—distance from metope face to triglyph face. At cornice level there will be insufficient room for the full width of the mutule, which will therefore be of reduced length and probably L-shaped. If, however, width of via + distance from outer edge of mutule to metope face = reduced width of metope, the mutule at the angle will be square (FIG. 1B).

A larger metope can be obtained by increasing the corner intercolumniation, a metope of the normal width resulting from an increase in the intercolumniation of

\[
\frac{2}{\text{thickness of architrave}}
\]

—setback of metope from triglyph. This width of metope creates difficulties in the cornice since there is likely to be a tiny square via in the re-entrant, entirely surrounded

* The following abbreviations are used in addition to the normal ones:

Delos: École française d'Athènes, Exploration archéologique de Delos.
Kos: R. Herzog, Kos: Ergebnisse der deutschen Ausgrabungen und Forschungen.
Magnesia am Maeander: C. Humann, Magnesia am Maeander: Bericht über die Ergebnisse der Ausgrabungen der Jahre 1891–1893.

1 Vitruvius IV. iii. 1.  2 D. S. Robertson, Greek and Roman Architecture 106–11.
by mutule. But if the distance from the inside edge of the mutule to the metope face equals the normal width of the *via*, this trouble will be avoided and instead there will be two mutules of normal width meeting in an L.

To enable two half triglyphs to meet at the re-entrant angle of the frieze, the corner inter-columniation must be increased even further, by $\frac{\text{thickness of architrave}}{2}$ (FIG. 2A). The treatment
of the cornice must depend on the amount of its projection. If the width of the half triglyph equals the distance from the outer edge of the mutule to the triglyph face, there will be room for a square mutule. If the width of the half triglyph + the width of the via equals the distance from the outer edge of the mutule to the triglyph face, there will be room for a square via (Fig. 2B).

A third possibility, placing two whole triglyphs next each other at the angle, would entail extending the angle intercolumniation even further, by $\frac{\text{architrave thickness}}{2} + \frac{\text{triglyph width}}{2}$.

There would also be an awkward angle between the end half grooves of the triglyphs unless
in fact three-quarter triglyphs were used. As far as I know this solution was used only once, in the upper story of the Stoa of Athena Polias at Pergamon.

So far, the only modification we have considered to the normal dimensions of the order is an increase in angle intercolumniation to expose more frieze. Exactly the same result is produced by reducing the width of the frieze elements near the re-entrant angle, and this alternative was sometimes used, either instead of, or in conjunction with, an increase in the intercolumniation.

The necessity to deal with the problems of a re-entrant angle arose early in Greek architecture. The North Stoa at the Argive Heraion has such a corner, but none of its entablature has survived to tell us how the angle was treated. The NW. Building at the Argive Heraion, belonging to the second half of the sixth century, must also have dealt with the problem, but again we do not know how. Further information would be given by the block of re-entrant frieze found in Corfu, but no details of its form are published, except that it is of archaic type.

The first details we get of the management of a re-entrant angle are from the Stoa Basileios at Athens (430–415) and the Stoa at the Artemision at Brauron (420–415), and it is interesting to see that these two buildings which are so close together in date choose completely different ways of dealing with the situation. This is because of the difference in the type of building in question, a point which will be discussed later.

First the Stoa Basileios: the most relevant measurements are as follows:

\[
\begin{align*}
\text{Normal intercolumniation} & \quad (3.018 \text{ m.}) \\
\text{Angle intercolumniation} & \quad (3.018 \text{ m.}) \\
\text{Triglyph width} & \quad 0.402 \text{ m.} \\
\text{Metope width} & \quad 0.604 \text{ m.}
\end{align*}
\]

Since there is no change in the angle intercolumniation, there must be two metopes meeting in the frieze, their length being \(0.604 - 0.05 - 0.015 = 0.48\) m. The width of the mutule above it would then equal \(0.48 - 0.05 - 0.015 = 0.31\) m. In fact a preserved cornice block from the re-entrant angle has a square mutule \(0.305 \times 0.305\) m. with nine guttae hanging from it. This confirms that this was in fact the treatment of the angle, and shows how carefully the architect had thought it out.

At Brauron the situation is quite different; the figures are:

\[
\begin{align*}
\text{Normal intercolumniation} & \quad 2.87 \text{ m.} \\
\text{Angle intercolumniation} & \quad 2.96 \text{ m.} \\
\text{Triglyph width} & \quad 0.39 \text{ m.}
\end{align*}
\]

A preserved block from the re-entrant angle of the frieze shows that two half triglyphs meet there, but the increase in the angle intercolumniation (0.09 m.) is not sufficient to allow this

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3 C. Waldstein, *The Argive Heraeum*, pl. xii.
5 *ADelt* i (1915), parart. 45.
6 *Hesperia* vi (1937), fig. 22.
7 The re-entrant angle is best shown in *Ergon* 1961, pl. 1.

The figures are taken from *PAE* 1950, 179–84.
without some contraction of the near-by frieze elements (Plate 27a). This contraction must amount to 0.68/2 — 0.09 = 0.25 m. How this was spread over the frieze elements is not entirely clear from the preliminary publications. The cornice above this frieze has no mutules or viae, a rather drastic solution of the problem at that level. It indicates that the architect was not quite at home with re-entrant angles, and contrasts strongly with the assured handling in the Stoa Basileios.

The reason for these two treatments can be found in the differences in the two building types and the way in which they would be seen. The Stoa Basileios would be viewed mainly from the front, and the number of points from which a clear view of the re-entrant angle could be obtained is very limited. Seen from the front, the Stoa Basileios would show a more or less even arrangement of columns (except for the contraction at the external angles) and an almost regular alternation of triglyphs and metopes. Since an elevation can never be seen as it is shown in an architectural drawing, the strongly foreshortened returning frieze would appear to make up the reduced corner metope to normal width. At Brauron, in a semi-enclosed court, the re-entrant corners assume much greater importance, and so in spite of the strong contraction of the metopes it entailed, it was found more satisfying to turn the corner with triglyphs, just as this was found more satisfying at external corners.

The distinction between the frontal Stoa Basileios type and those buildings with two or more main façades meeting at re-entrant angles is fundamental to the study of such angles. The visual problems involved are quite separate and we cannot use the treatment of re-entrant angles in a building of one type as evidence for the arrangement in one of the other type. L-shaped stoas, even where one arm is comparatively short as in the Stoa by the Harbour at Miletos, belong very much to the second group.

More is known about the re-entrant angles of the second group so it will be treated first. The relevant measurements for some of the later buildings of this type in Mainland Greece are as follows:

<table>
<thead>
<tr>
<th>Building</th>
<th>Normal intercolumniation</th>
<th>Angle intercolumniation</th>
<th>Lower diameter</th>
<th>Triglyph width</th>
<th>Metope width</th>
<th>Architrave thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olympia</td>
<td>2.69 m.</td>
<td>3.006 m.</td>
<td>c. 0.80 m.</td>
<td>0.342 m.</td>
<td>0.404 m.</td>
<td>c. 0.75 m.</td>
</tr>
<tr>
<td>Leonidaion*</td>
<td>2.73 m.</td>
<td>3.50 m.</td>
<td>c. 0.80 m.</td>
<td>0.555 m.</td>
<td>0.598 m.</td>
<td>c. 0.75 m.</td>
</tr>
<tr>
<td>Athens Peristyle Bdg.5</td>
<td>2.302 m.</td>
<td>2.387 m.</td>
<td>0.625 m.</td>
<td>0.306 m.</td>
<td>0.462 m.</td>
<td>0.50 m.</td>
</tr>
<tr>
<td>Perachora Stoa</td>
<td>2.05 m.</td>
<td>2.28 m.</td>
<td>0.59 m.</td>
<td>0.255 m.</td>
<td>0.429 m.</td>
<td></td>
</tr>
<tr>
<td>Epidauros Hotel11</td>
<td>2.05 m.</td>
<td>2.28 m.</td>
<td>0.59 m.</td>
<td>0.255 m.</td>
<td>0.429 m.</td>
<td></td>
</tr>
</tbody>
</table>

In the Leonidaion, the increase of 0.04 m. in the angle intercolumniation gives a metope width of 0.555 — 0.72 — 0.342/2 + 0.04 + 0.045 (setback of metope) = 0.451 m. A frieze block with two metopes 0.445 m. wide meeting at a re-entrant angle has been found. A Doric cornice block from a re-entrant angle is shown in the publication, with an L-shaped via at the corner.12 The length of this via should be 0.445 — 0.45 (setback of metope) — 0.047 (distance from inner edge of mutule to triglyph face) = 0.353 m. In fact it is shown as 0.33 m.; it is not clear how this difference should be explained. The Palaistras at Epidauros13 and at Olympia14 follow the

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8 *Olympia*, Text II 87, Plates II, pl. lxiv.
9 Figures kindly given to me by Prof. H. A. Thompson. The re-entrant frieze fragment attributed to the SW. Fountain in *Hesperia* xxiv (1955) 53 in fact belongs to this building.

10 BSA lix (1964) 109–11.
11 Figures obtained from the surviving remains of the building.
12 *Olympia* II, pl. lxiv. 8.
13 *PAE* 1901, pl. 1.
14 *Olympia*, Plates II, pl. lxxiii.
Leonidaion in having two metopes of reduced length meeting at the re-entrant angles, but in neither case is the angle intercolumniation increased at all.

In the other three buildings mentioned above the considerable increases in the angle intercolumniation show that two half triglyphs meet at the re-entrant angles. The formula given above for this fits exactly in the Stoa at Perachora, whereas in the Peristyle Building at Athens the increase in intercolumniation ought to be \( c \cdot \frac{0.75}{2} = 0.375 \) m.; in fact it is 0.494 m. Perhaps two three-quarter triglyphs rather than half triglyphs should be restored at the angle; otherwise there must have been considerable adjustment in the frieze elements near the corner.

A completely new solution was developed in Ionia which was used regularly in the L-shaped stoas and colonnaded courts of the area. It involves the use of a heart-shaped pier made up of two half-columns attached to adjacent faces of a square pillar. Since this pillar is the same width as the lower diameter of the column and so slightly wider than the thickness of the architrave, there is ample room for two half triglyphs to meet at the re-entrant angle without increasing the intercolumnar space next the angle or reducing the width of any frieze elements.

The Stoa by the Harbour at Miletos, which is the earliest example of this treatment, is also one of the clearest, for the frieze and cornice blocks from the re-entrant angle have survived. Since the square pillar of the heart-shaped pier is 5 centimetres wider than the architrave thickness, there is 2.5 cm. more space than necessary for two exactly half triglyphs at the angle, so that the two flat bands ('meroi') of the half triglyphs meeting at the angle were not of half width but of full width. The cornice has its normal viae and mutules over the metope next the corner, but over the two half triglyphs there is a square via, conveniently decorated with a palmette.

The heart-shaped pier seems thus to solve the problems of the re-entrant angle with great ease, but it raised fresh problems of its own. First, in the shaft; if the four faces of the imaginary square pillar all slanted inwards, then the half-columns, both themselves tapering and applied to a slanting surface, would have twice as much slant as the faces of the pillar (FIG. 3A). If, as in fact happened, only two faces of the square pier were slanting and the two faces to which the half-columns were applied were imagined as vertical, then the edge between them should be vertical too, and, as the half-columns tapered, should project in the re-entrant angle of the pier (FIG. 3B). In the Agora at Magnesia on the Maeander, where the heart-shaped pier was also used, this was allowed to happen and the projecting angle continued even in the capital (FIG. 4A). At Miletos, however, where the capital from the corner pier of the South L-shaped Stoa of the North Market survives, a less distracting, though less mathematical, result was obtained by allowing a small notch to appear between the two half-columns as they tapered. To keep the notch as small as possible, the fluting of the half-columns was stretched towards the top, so that the five flutes next to the re-entrant angle cover rather more than a quadrant, although the other five flutes occupy an exact quadrant (FIG. 4B).

A further difficulty arose with the capital. Normally a rectangular pier, even with a half-column attached, would be given a capital of the same type as an anta. But in an otherwise normal colonnade this disunity in the corner capital, a focal point, was unacceptable, and instead the square pier was given an abacus identical with that of the columns, and below that, a set of mouldings with the same height and projection as the echinus of the columns.

A few variations of the standard heart-shaped pier were tried. Simplest was to bevel off the angle of the pier, as was done at the Palaistra by the Lake at Delos (FIG. 5A). A more subtle

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15 Milet i. 6. 7–12, figs. 12, 14, 16, 18, pl. x.
16 Magnesia am Maeander 120.
17 Milet i. 6. 24, where the problem is discussed.
18 e.g. in the S. Stoa at Olympia (Olympia I, pl. i.i 1.2).
19 Delos xxv. 123–8.
FIG. 3. THE HEART-SHAPED PIER

(a) All four faces of the square pillar incline equally, giving the half-columns double inclination. (b) The square pier has two vertical faces, producing a projecting angle between the two half-columns

FIG. 4(a). CAPITAL OF THE PIER FROM A RE-ENTRANT ANGLE OF THE AGORA AT MAGNESIA ON THE MAEANDER. (Based on Magnesia am Maeander 120, fig. 126.)

(b). CAPITAL OF THE PIER FROM THE RE-ENTRANT ANGLE OF THE SOUTH STOA OF THE NORTH MARKET, MILETOS. (Based on Milet i. vi. 24, fig. 26.)
variety was used in the Shrine of the Royal Cult at Pergamon.20 Here, instead of a square pier, it is a column which is placed at the corner, with two further columns struck out from points on the lower circumference of the first, so that the centres of these three intersecting columns formed a right-angled triangle (FIG. 5A). Since all the parts of this pier were columns, there would be no difficulty over the capital, and as all three columns tapered towards the top, the re-entrants where they met deepened, but there was no ugly edge to appear as in the heart-shaped pier at Magnesia on the Maeander. Thus both the problems occurring in heart-shaped piers were solved without any ungeometrical fiddling.

There are also two ways of arranging the flutes on the half-columns. In the Stoa by the Harbour at Miletos, there are whole flutes next to the edge of the pier, so that an arris falls under the middle of each face of the abacus (cf. FIG. 4B). In the Agora at Magnesia on the Macander there are more correctly two half flutes next the edge of the pier, and a flute under the middle of the abacus sides (FIG. 4A).

The heart-shaped pier found considerable favour in Asia Minor and the lands under its influence. Besides the five examples already mentioned, definite evidence of such corner piers (traces on the stylobate or surviving drums) has been found in the South L-shaped Stoa of the North Market21 and the North L-shaped Stoa of the South Market22 at Miletos, the ‘Bouleuterion’ at Magnesia on the Maeander,23 the Agora at Herakleia on Latmos,24 the Sanctuary by the Harbour at Kos,25 the Tetrastoon by the Theatre at Lindos,26 the House by the Lake at Delos,27 the North-west Stoa at Aigai,28 a peristylar court at Knidos,29 and the portico round the temple of Athena at Notium.30 All the examples so far are in the Doric order, for which this type of pier seems to have been devised. It was, however, used in Ionic too.

It is not surprising to find a heart-shaped pier in the Ionic upper story of the North-west Stoa at Aigai, since the Doric lower story also used such a pier. There is, however, no such excuse for the heart-shaped piers in the Agora at Aphrodisias,21 which also has Ionic colonnades. Yet we
must remember that the Ionic capital presented its own problem in turning a corner. For an external corner, this was solved satisfactorily enough by placing two volute faces next each other, as in the Temple of Nike on the Athenian Acropolis, but a capital of this type cut a very poor figure at a re-entrant angle. Although such capitals were used at the angles of the court of the House in Section I at Pella, it is understandable that architects tried other devices. A capital with four volute faces might be used, but to place a volute face under the architrave, as this does, makes nonsense of the shape and apparent purpose of an Ionic capital. The capital from Aphrodisias shows the advantage of a heart-shaped pier in Ionic. For instead of just two half volutes, it has two half volute faces showing on to the Agora. The echinus, canalis, and abacus of the inner volute faces are continued along the flat faces of the pier to meet at the right angle.

Later, there are several examples of the heart-shaped pier in the Corinthian order, and here the reason must either be force of habit or a positive liking for such a pier, for both the capital and entablature of a Corinthian order can deal with any sort of corner without difficulty. Corinthian examples are found in the court of the Temple of Bel at Palmyra, the court of the Temple of Artemis at Gerasa, the Palace of the Columns at Ptolemais, and the House of Jason at Cyrene.

It is the more remarkable how tenaciously such architects clung to this form of pier, because it was never accepted in Mainland Greece. The only pier from a re-entrant angle related to it that we know of is that from the upper story of the L-shaped Stoa at Perachora. In this case, because the upper order was of attached half-columns, a special pier was needed to turn the corner since an attached half-column could not show two identical faces to the two colonnades. It was necessary either to use an L-shaped pier with a quarter-column in the angle, or to split a normal pier lengthwise and attach the two halves to adjacent sides of a square pillar. Since the first alternative would have given a very weak capital, the second was in fact chosen. Apart from this one case the Mainland Greeks used a normal circular column at the re-entrant angle.

Even in areas quite close to the Ionian homeland of the heart-shaped pier, it had only a limited popularity. Among the many peristylar courts at Delos, only two are known to have

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32 Dinsmoor, fig. 69.
33 ADelt xvi (1960), pl. XLI.
34 T. Wiegand et al., Palmyra: Ergebnisse der Expeditionen von 1902 und 1907, pl. LXVII.
35 C. H. Kraeling, Gerasa, City of the Decapolis, 132.
36 G. Pesce, Il 'Palazzo delle Colonne' in Tolemaide di Cirenaica, pl. r.
37 AA lxxxiv (1959) 310.
38 BSA lix (1964) 117, fig. 6 c, d. A normal heart-shaped pier was used at the external angle of the same colonnade (ibid.).
used the heart-shaped pier, a normal circular column being otherwise preferred. The Delians seem to have devoted little attention to the problems involved in re-entrant angles.

The Agora of the Italians has circular corner columns of normal diameter and no increase in the angle intercolumniations. However, the architect insisted on two half triglyphs meeting at the angle and obtained the necessary space by reducing the width of the metopes and triglyphs over the last intercolumniation. In the cornice the width of the mutules follows the varying width of the frieze elements, and in the angle above the two half triglyphs is a square via decorated with a palmette.

The Establishment of the Poseidoniasts has an even more irregular peristyle, the intercolumniations of which vary largely. The corner columns are normal with two half triglyphs meeting above them, and most of the angle intercolumniations are increased. However, on the west side of the court they are reduced, and it is quite clear that no attempt has been made to work out the angles rationally. The width of the frieze elements varies as necessary, and the irregularities near the angles are by no means the only ones. The situation above the frieze is simplified by using a cornice without mutules as at Brauron.

The House of Kerdon, the only Delian house where a full stone entablature survives, also avoids problems with the same sort of cornice. But here it seems that two reduced metopes meet at the angles, for there is no increase in the angle intercolumniations, and the surviving frieze elements are too regular to suggest a treatment like that at the Establishment of the Poseidoniasts.

The heart-shaped pier was not much used at Pergamon either. At the re-entrant angles of the Lower Agora and the Stoa of Athena Polias there is a circular column. In the Lower Agora the angle intercolumniation is increased from 2.33 m. to 2.52 m. The architrave thickness is c. 0.48 m., so that the increase of 0.19 m. in the angle intercolumniation is less than the 0.48/2 = 0.24 m. necessary to bring two half triglyphs together in the frieze. On the other hand the increase is more than \[\frac{\text{architrave thickness} - \text{triglyph width}}{2}\], that is \[\frac{0.48 - 0.26}{2} = 0.11\ m.,\]

which is necessary to produce two whole metopes at the re-entrant angle. We have insufficient data to work out what did happen, but Dörpfeld's drawing suggests that a slight reduction in the metope width near the corner brought two half triglyphs together. In the Upper Agora even less can be calculated, for the angle intercolumniation is unknown.

The Stoa of Athena Polias is more interesting, for in addition to increasing the angle intercolumniation, the architect also increased the diameter of the angle column from 0.69 m. to 0.78 m., giving it twenty-four flutes instead of twenty. The other figures are as follows:

- Normal intercolumniation 2.50 m.
- Angle intercolumniation 2.94 m.
- Architrave thickness 0.59 m.
- Triglyph width 0.265 m.
- Metope width 0.36 m.

The increase of 0.44 m. in the angle intercolumniation is much more than the 0.295 m. needed to bring two half triglyphs together at the angle; an increase of 0.44 m. could be needed only if two whole triglyphs meet at the angle, which would demand

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39 Delos xix, 19–25, figs. 20, 24.
40 Delos vi, pls. vi, viii.
41 BCH xxix (1905), pl. xi. The arrangement suggested is confirmed by the architrave block shown in pl. xi. 5.
42 AM xxvii (1902) 21, fig. 2.
43 Pergamon iii, 1, pl. xxiv. But in pl. xxxiv J. Schrammen suggests an increased intercolumniation at the angles.
44 Pergamon ii, pl. xvi.
an increase of \( \frac{\text{architrave thickness} + \text{triglyph width}}{2} \) = 0.43 m. This is a most unexpected result, since we have seen that in all the other re-entrant angles either two metopes or two half triglyphs meet at the re-entrant angle.

However, another solution is possible. Bohn records an architrave fragment\(^{45}\) with regulae 0.292 m. wide and spaced 0.387 m. apart (corresponding to a frieze unit of 0.679 m.) and attributes it to the east wing, to the span at the re-entrant angle. With such frieze units, the normal intercolumniation would be \( 4 \times 0.679 = 2.716 \) m., so that the angle intercolumniation of 2.94 m. represents an increase of only 0.224 m. Then if not all the frieze units above the angle span were extended so much, there could be two half triglyphs meeting at the angle. A difficulty here is that on the face of this fragment are the letters ΔΙ probably from the end of an inscription dedicating the stoa to Athena Polias. In view of the great length of the north wing (27 intercolumniations with space for 108 letters) it is strange that a few letters had to be carried round the corner to the east wing.

In the upper story too there is evidence for a variety of frieze units. An epistyle-frieze fragment is preserved with one end bevelled,\(^{46}\) showing its position was in the east wing next the re-entrant angle. The width of its triglyph (0.225 m.) and its metope (0.318 m.) are greater than necessary for the normal intercolumniation \( (0.215 \text{ m. and } 0.285 \text{ m.}) \) and the width of five of its triglyphs and metopes would be 2.715 m., so that the angle intercolumniation of 2.94 m. represents an increase of only 0.225 m. The preserved fragment shows that there was definitely a whole triglyph (0.215 m. wide) next the angle, and this in theory demands an increase of half the thickness of the architrave plus half the width of the triglyph, which would be \( \frac{0.336 + 0.22}{2} = 0.278 \) m., so the other triglyphs and metopes over the angle span must have been slightly less than 0.225 and 0.318 m. wide. This definite use of wider frieze units next to the angle in the upper story supports Bohn’s theory of wider frieze units, and so two half triglyphs, next to the angle in the lower story; it is only in the upper story therefore that we have two whole triglyphs at the angle, and since this is the only case where a two-storied stoa with triglyphs in the upper as well as the lower entablature turns a re-entrant angle, the re-entrant angle with two whole triglyphs may well be unique. Certainly I have come across no other case of it.

In Kos, too, normal columns were used at the re-entrant angles of the two great π-shaped stoas of the Asklepieion.\(^{47}\) In the Lower Stoa, Schazmann’s figure shows that the angle column was of the normal size, but the axial distance from the angle column to the next preserved column trace is shown as 7.5 m., 0.33 m. more than necessary for three spans of the normal length of 2.39 m. The architrave thickness is c. 0.50 m., but with some extension of the near-by frieze units an angle with two half triglyphs could be obtained.

The treatment of re-entrant angles in peristylar courts and L-shaped stoas was thus not standardized, but there was a general preference for two half triglyphs meeting in the frieze, and in Asia Minor the angle support often received special treatment. One fact appears to be invariable: the treatment of both sides of the re-entrant angle was the same.

When we come to consider the treatment in stoas with projecting wings the situation is quite different, although on the whole there are fewer facts to work on. In the Stoa of Philip at Megalopolis\(^{49}\) the central part of the building is set 4.115 m. back from the wings, an amount divisible almost exactly by the normal intercolumniation of the wing (2.05 m.). Of the two

\(^{45}\) Pergamon ii. 35, pl. xxi 5.  
\(^{46}\) Ibid. 39, pl. xxiii 7.  
\(^{47}\) Kos 16.  
\(^{48}\) Kos 64-65, fig. 38.  
\(^{49}\) Megalopolis 62-63, pl. xv.
intercolumniations which occupied each return, the one next to the front of the wing was presumably contracted in the normal way by \( \frac{\text{architrave thickness} - \text{triglyph width}}{2} \) in order to turn the external angle. So unless the frieze elements on the return were of abnormal width, the other span of the return must have been increased by the same amount, and this, as we have seen, would mean that in the frieze above the return there was a whole metope next the re-entrant angle. However, along the façade of the central part of the stoa there is every reason to believe that the colonnade was entirely regular with no increase in the angle intercolumniation, for the internal bases are placed quite regularly even at the end of the building. Therefore, in the frieze above the central part, the metope next to the corner must have had its width reduced by \( \frac{\text{architrave thickness} - \text{triglyph width}}{2} \). We have therefore an arrangement which is not symmetrical about the angle.

The Paraskenia Building at Thasos raises more complicated problems. Both triglyphs and metopes vary in size, most of the blocks falling into two groups, those with triglyphs 35-35-8 cm. wide and metopes 52-4-54 cm. wide, and those with triglyphs 37.5-38 cm. wide and metopes 58-8-61 cm. wide. The mutules and viae vary similarly. Most of the frieze entablatures are illustrated by Martin and from these it is obvious that he is right in restoring the wings with four columns and a normal axial span of \( 1.93 \) m., so making use of most of the blocks with larger frieze elements: architrave 118, frieze blocks 117 and 128, and cornice blocks 137 and 141.

Martin's restoration of the central part of the building and the returns is less satisfactory. He restores three triglyphs and two very much reduced metopes (width 39 cm.) on the returns, and in the central portion eight triglyphs and seven metopes of slightly extended width. These are supported by four columns with intercolumniations of 2.52, 2.91, and 2.52 m. The first objection to this arrangement is that in the cornice above the returns there is not room for normal mutules and viae above the metopes. The mutules must be very strongly contracted, or, as Martin's drawing suggests, omitted. There is no good parallel for either. Second, there is only one other instance of two whole triglyphs meeting at an internal angle, and that in a building of a completely different type. Such a junction must be extremely awkward. Third, the arrangement of the columns with axial spans of about two and a half, three, and about two and a half frieze units is unusual, and derives no firm support from the stylobate jointing, since, though the columns do not fall on the joints, they are by no means centred on the blocks. The problems deserve re-consideration.

Since Martin's publication a new fact has come to light: it has been found that frieze blocks 130 and 129 join each other (Plates 27a, 286), and since the left-hand end of block 130 is broken, there was probably a further triglyph at that end, making the original beam consist of three metopes and three triglyphs. One might have supposed that block 133, as the only long frieze block, belonged to a three-metope span, and therefore to the centre of the building, where alone a three-metope span is possible. We now find, however, that block 130+129 is at least as long and so at least as likely to have come from a three-metope span. Yet blocks 133 and 130+129 certainly cannot both come from the central part since they have metopes and

50 See p. 132 above.
51 They are well presented by Martin in Thasos, l'Agora 72-80. I refer to the blocks by the numbers given to them there.
52 Narrower mutules over the metopes were sometimes used in the archaic period (e.g. Temple C at Selinus, Dinsmoor, fig. 29), never in the classical or Hellenistic periods.
53 The upper story of the Stoa of Athena Polias at Pergamon. This is the only L-shaped stoa with a two-storied portico to use triglyphs in the upper story.
triglyphs of different sizes (block 133: metope width = 0.605 m.; triglyph width = 0.375 m.; block 130 + 129: metope width = 0.525 m.; triglyph width = 0.36 m.); at least one of them must belong either above the walls or to the two-metope spans of the wings, so that the length of frieze block cannot be taken to prove the existence of a three-metope span; and in restoring the central part of the frieze we are now free to use (a) either two- or three-metope spans, and (b) either the larger or smaller frieze elements, whichever should prove more suitable.

The key to the problem is frieze block 132 with its very short metope. We have seen\(^\text{54}\) that in the Stoa Basileios at Athens two reduced metopes meet at the re-entrant angle. It is natural therefore to place block 132 with its metope 0.39 m. wide next the re-entrant angle. If it is placed in the return frieze, the preserved triglyph and metope take up only 0.752 m., and the single metope and triglyph, which would have to occupy the remaining 1.80 - 0.752 + 0.034 = 1.082 m., would be disproportionately large. The central part of the building may be more suitable. It is possible to restore this either with three equal spans, the central one having three metopes, or with four equal spans, the two central ones having two metopes. Since the axial width of the central part of the stoa is 7.95 m., the spans will be 2.65 m. or 1.988 m. respectively, giving frieze units of 0.881 m. or 0.93 m. The first figure suits the smaller triglyphs and metopes, and the second suits the larger ones. Since we now intend to use frieze block 132 in the central part, the width of its triglyph (0.356 m.) decides for the restoration with three spans of three metopes. The figures for the re-entrant angle are therefore:

- Normal intercolumniation 2.65 m.
- Angle intercolumniation 2.65 m.
- Architrave thickness 0.685 m.
- Via width 0.085 m.
- Triglyph width 0.356 m.
- Metope width 0.525 m.
- Setback of metope 0.034 m.
- Via face to outer edge of mutule c. 0.265 m.

Working from these figures, we should expect the reduced metope at the angle to measure

\[
0.525 - \frac{0.685 - 0.356}{2} + 0.034 = 0.394 \text{ m., almost exactly the width of the metope of frieze block 132.}
\]

The frieze along the returns has a length of 1.80 + 0.034 = 1.834 m. This could well be occupied by two triglyphs c. 0.365 m. wide and two metopes c. 0.55 m. wide. Though triglyphs and metopes with these widths would belong to neither group of frieze elements, there is nothing unlikely about them. So this building, too, like the Stoa of Philip at Megalopolis probably had re-entrant angles with a reduced metope on the main face and a full-sized metope on the return of the building (FIG. 7).

The regular placing of the internal column bases in the Stoa of Antigonos at Delos\(^\text{55}\) suggests that here, as at Megalopolis, there was no increase in the external intercolumniation of the central part of the stoa next the re-entrant angle; therefore in the frieze above the central part there was a reduced metope next the angle. The length of the return, 6.0 m., to be divided between two intercolumniations more or less rules out the possibility of such reduced metopes next the angle in the frieze above the returns, even if we allow for the elastic treatment of the metopes in this building. So here too we must restore a frieze where the elements are not placed symmetrically about the re-entrant angle.

Lindos provides two further examples of the stoa with projecting wings. For the Propylaia, too little information has survived for us to gain any idea of the treatment of the re-entrant angles,\(^\text{56}\) but it is reasonable to suppose that it was the same as the Stoa. As in the Stoa of Philip

\(^{54}\) See p. 135 above.  \(^{55}\) Delos v, pl. 11.  \(^{56}\) Lindos III i, fig. v i.
FIG. 7. PARASKENIA BUILDING AT THASOS. PROBABLE ARRANGEMENT OF THE FRIEZE
at Megalopolis, the setback of the central part (10.48 m.) of the Stoa at Lindos is divisible by the normal intercolumniation (2.62 m.). By the same line of reasoning, therefore, we may assume that here too there was a whole metope next the re-entrant angle in the frieze above the return. But here too there was no increase in the angle intercolumniation of the central part, for a column found in situ near the north-west end of the central part is shown as c. 5.20 m. (= 2 x 2.62) from the axis of the angle column. So above the central part there was a reduced metope next the angle.

Thus, as far as it goes in each case, the evidence suggests for all these stoas the same asymmetrical treatment of the re-entrant angle, with a full metope in the return frieze and a reduced metope above the central part. Such a solution may seem aesthetically unsatisfactory, but would be far less so in a stoa of this type than in an L-shaped stoa or peristylar court, where the re-entrant angle is an emphatic point. It would also simplify the task of the architect if the length of the returns were a multiple of the normal intercolumniation, with the contracted span at one end offset by the increased span at the other. The axial length of the central part, if there was no variation of the angle span, would also be a multiple of the normal intercolumniation, an advantage which would be lost if the angle intercolumniations were increased to match those of the returns.

This arrangement does, however, raise one question to which no definite answer can be given. The full-width metope on the return demands a via next the re-entrant angle in the cornice above it, while the reduced metope of the main façade should have a reduced mutule above it. The width of the via demanded in the return cornice is in fact reduced by the distance from the metope face to the inner edge of the mutules, so that a mutule with a comparatively small increase in its width would reach right into the angle and so answer the demands of both metopes more or less (cf. r10. 7b); this is a makeshift rather than a satisfying solution, but it is difficult to suggest anything better. No cornice fragment from such a re-entrant angle survives to help us.

In view of the distribution of the buildings I have discussed, it may be tempting to suppose that local taste played as important a part as type of building in deciding on the treatment of a re-entrant angle. It is true that L- and pi-shaped stoas are more common in Asia Minor, where they are used to great effect in agoras of the Ionian type, while stoas with wings (more suited to an agora 'in the older style, with separate colonnades and streets between them') are found mainly outside the Ionian sphere of influence. However, this local division is not absolute; L- and pi-shaped stoas are found in the same area as those with projecting wings (e.g. L-shaped Stoa on the Agora at Delos, Stoa at Perachora, Stoa at Brauron, etc.) and peristylar courts occur over the whole Greek world. Yet in these cases the treatment of the re-entrant angle varies according to type not place. Indeed we have only to imagine the asymmetrical re-entrant angle in an L-shaped stoa or peristylar court, or the heart-shaped pier in a stoa with projecting wings, to realize that the type of building must be the dominant factor.

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57 Lindos III i, pl. VI A, VI H. The comparative material above is against Baumann's restoration with spans of 2.56 m. along the returns.
58 In the Stoa at Lindos the via width is almost the same as the distance from the metope face to the inner edge of the mutules, so no such increase would be necessary.
59 Pausanias, vi. 24. 2 (trans. Frazer).
60 Besides the stoas with projecting wings dealt with above, there are similar buildings at Mantinea ('Bouleuterion'; BCH xiv (1890) 256-60, G. Fougères, Mantine et l'Arcadie orientale 174-7) and at Kalauria (Stoa F; AM xx (1895) 281-3, G. Welter, Troizen und Kalaureia 51).
61 BCH xxi (1902) 490-500.
62 e.g. Peristyle Building at Athens (pp. 136-7 above), Leonidaion at Olympia (ibid.), Agora of the Italians at Delos (p. 141 above), Tetraestoon by Theatre at Lindos, Peristylar Court at Knidos (p. 139 above).
THE TREATMENT OF RE-ENTRANT ANGLES

(a) The stoa at the Artemision, Brauron, re-entrant angle

(b) Paraskenia building at Thasos: block 130 (left) and left-hand fragment of block 129
THE TREATMENT OF RE-ENTRANT ANGLES
Thasos, Paraskenia building, block 129, right-hand fragment

AN EGYPTIAN FLINT KNIFE FROM KNOSSES