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Article Author: Vatican City. Direzione generale dei monumenti, musei e gallerie pontificie.
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MONUMENTI MUSEI E GALLERIE PONTIFICIE

BOLLETTINO

III

TIPOGRAFIA POLIGLOTTA VATICANA
1982

THE STRUCTURE OF A HOPLITE SHIELD IN THE MUSEO GREGORIANO ETRUSCO

BY
HENRY BLYTH

The remains of wood and leather in a round shield in the Vatican's Museo Gregoriano Etrusco (figs. 1-2)[1] allow us to reconstruct the entire shield with some certainty; the result is unexpectedly light and elegant in its design, and provides an insight both into hoplite warfare and into ancient craftsmanship. The methods used in the shield's manufacture have been discussed by A. Rieth;[2] in this paper I shall add a little to that discussion but concentrate mainly on functional aspects of the design, arguing that the strength and resistance of the shield are evidence both of the requirements of hoplite warfare and of the ability of craftsmen to meet them.

The provenance of the shield is probably a tomb in Pianmiano, a hill above Bomarzo, near Volsinii, which was opened by a private excavator in 1830.[3] If so, it was accompanied by a helmet and greaves, which are now untraceable. It is entirely undecorated, and can be dated only from the shape of the bronze cover and internal fittings. Dohrn[4] suggests the Vth-IVth centuries BC, Magi,[5] in a discussion which will be followed here, prefers the Vth BC.

The bronze cover, which is about 0.5 mm thick, forms a shallow bowl about 10 cm deep and between 81.5 cm and 82 cm in diameter,

[1] Inv. n. 12328. This paper is based on two examinations of the shield, one by Dr. G. Jeronimidis of the Department of Engineering, University of Reading, who has generously placed his notes at my disposal, and one by myself when a research fellow of the same Department supported by the Leverhulme Trust. I thank Prof. F. Roncalli for the opportunities to examine the shield, for figs. 1, 2 and 3, and for the reference to Baglione's treatment (note 3 below) which served as a guide to other Etruscan material.

[2] *Ein Etruskischer Rundschild*, AA 1964, pp. 102-109, figs. 1-4.

[3] M.P. Baglione, *Il Territorio di Bomarzo*, Rome 1976, pp. 143-145.

[4] In Helbig, *Führer I*, n. 680, p. 515.

[5] F. Magi, *La Raccolta Benedetto Guglielmi nel Museo Gregoriano Etrusco*, II, Città del Vaticano 1941, pp. 225-227.

including a rim which projects about 4.5 cm from the wall of the bowl all round. The rim is marked off from the bowl by a groove about 2 mm deep, but is otherwise plain, and at its outer edge the metal is bent round the wooden core and flattened on the rear side so as to sheath

Fig. 1. Bronze shield from Bomarzo, inv. n. 12328. View of the exterior (Neg. XI-5-14)

that too, for a distance of about 4 cm. (The reduction of diameter involved in this process has been achieved without leaving wrinkles, overlaps or cuts, which argues considerable skill). The internal fittings were at one time loose, as Magi shows (p. 225 ff.), and have been reattached in recent times. They consist of two pairs of staples for the attachment of braided hand-grips, and a support for the central arm-band. The staples for the hand-grips are cut from bronze sheet, and end in roughly circular plates each of which is attached to the wood by three rivets. They have also been cemented to the wood, probably recently. The fitting for the central arm-band is also formed from bronze sheet; in the middle it is reduced to a narrow strap, about 1.5 cm wide, which must have fitted over a leather band about 10 cm

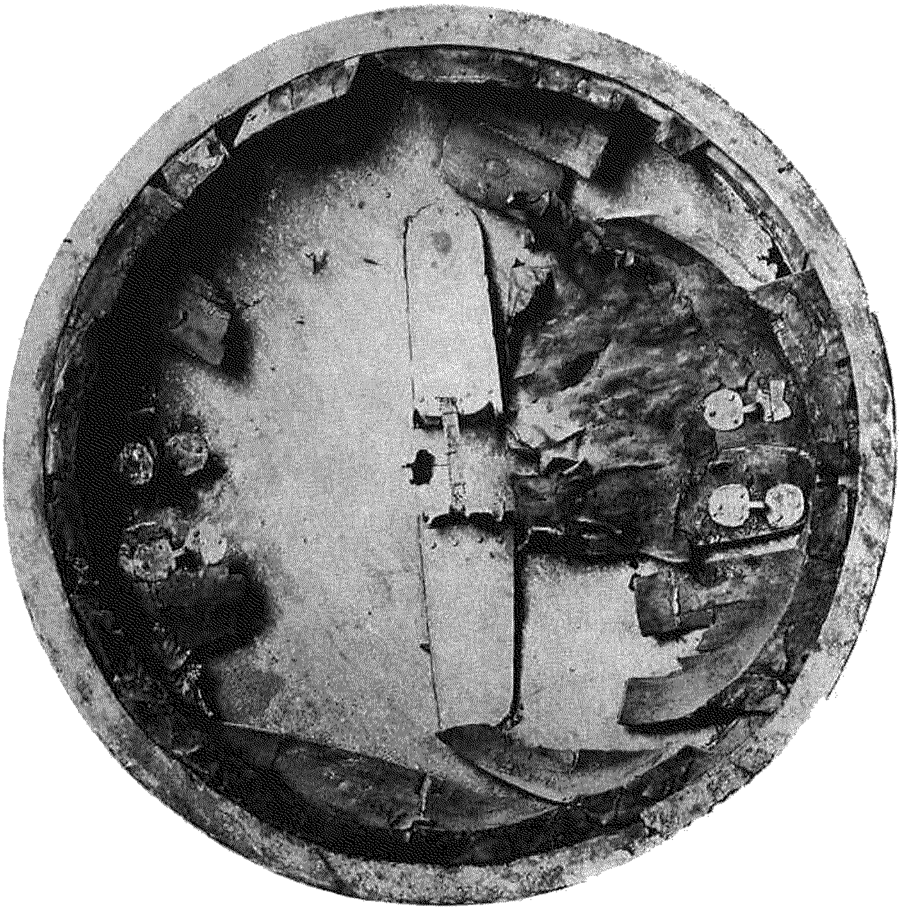

Fig. 2. Bronze shield from Bomarzo. View of the inside (Neg. VII-26-7)

wide, whose ends were attached to the bronze where it widens for about 2.5 cm before bending sharply to form two long flanges which taper slightly to semicircular ends. These flanges were attached to the wood by two rows of rivets on either side, all the rivets being close to the arm-band itself. The portion of the attachment between the central strap and the flanges has small holes for the sewing on of the leather, and is also curved to accommodate the seams on either side. Thus, while the profile of the bowl is similar to that in the shield from the

Tomb of the Warrior at Vulci [6] (though that is slightly deeper) and also to those of VIth century BC shields at Olympia,[7] it is not as shallow as that of the IVth century BC shield from the tomb of the Velii at Florence.[8] On the other hand the narrow strap of the arm-band suggests a date somewhat later than that of the shield in the Warrior Tomb, where the arm-band is wide. In addition to a second example in the Vatican,[9] which seems to be associated with staples of a type very similar to those found here,[10] and which has a scalloped decoration not easy to date, other narrow arm-bands have now been published from Olympia.[11] These must be earlier than 450 BC, when the shields were buried, but the decoration of the flanges is confined to a raised line close to the rim, which is reminiscent of the severe style of the Late Corinthian helmet and so probably fairly late.

Thus a date somewhere in the Vth century BC seems probable, provided that we accept the proposition, at first sight rather puzzling, that Etruscan fashions followed those in mainland Greece rather closely where structural innovations were concerned, but not in aesthetic matters. The Etruscan rims are all plain; those in Greece are always decorated, either with a guilloche or with a pattern of raised bosses which seem a degenerate version of the guilloche.[12] The Etruscan fittings are often plain and even crude; in Greece the decoration may be reduced to a minimum, as when the plates holding the staples are merely cut to an interesting shape, but it is never wholly absent, and often exuberant. It is difficult to imagine our shield being produced in a Greek workshop, even one working to special orders for export, as we know happened in the case of pottery at Athens, and as may have happened with the Illyrian helmet. Although Ferraguti has shown that it is unlikely that there was a bronze industry in Vulci,[13] because of the great variety of bronze-ware found in the tombs, it may

[6] U. Ferraguti, *I Bronzi di Vulci*, *St. Etr.* XI (1937), p. 116 ff. The tomb is dated by pottery to the end of the VIth or early in the Vth century BC.

[7] E. Kunze, *Olympia-Bericht* I (1937-8), p. 70 ff.

[8] G.C. Conestabile, *Pitture Murali*, p. 127, tav. 12, 7; U. Tarchi, *L'Arte etrusco-romana nell'Umbria e nella Sabina*, Milano 1939, tav. 25.

[9] Magi, *op. cit.*, p. 225, n. 113.

[10] *Ibid.*, p. 227, n. 114.

[11] Kunze, *Ol. Ber.* III (1959), pp. 90-92, fig. 85 and Taf. 29.

[12] Kunze, (*Ol. Ber.* V (1956), p. 57) comments that rims which have only a row of bosses are nearly always confined to shields either from Magna Graecia or in which the internal fittings are made of iron. His remarks on the almost universal excellence and exuberance of the decoration on the Greek rims reveal the wide gap between the Greeks and their neighbours, in such matters.

[13] Ferraguti, *art. cit.*, pp. 107-120.

be that there were local armouries in which a leading part was taken by craftsmen acquainted with the latest Greek techniques, but which also had to employ less highly trained men. For such travelling craftsmen we have the example of Cephalus, who was brought to Athens by Pericles to establish a shield-factory,[14] and there is some reason to suppose a similar explanation for the relation between the Etruscan helmet and the Late Corinthian, in both of which the crown starts to bulge outwards from the head at about the same time, though the

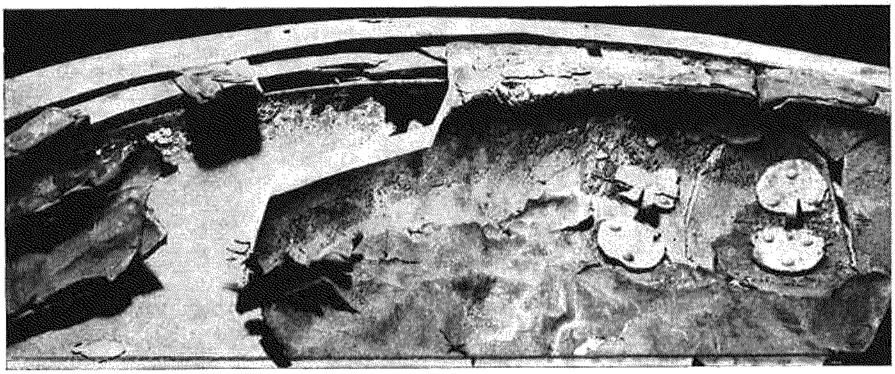

Fig. 3. Bronze shield from Bomarzo. Inside: detail of rim

aesthetic values are very different. Indeed, if Ferraguti is right in thinking that what has previously been described as the cheek-piece of a helmet[15] was in fact part of a shield, that shield and the helmet must have come from the same workshop, for both have similar palmettes, and that again suggests local production, since helmets must be made to fit.

Before leaving the bronze, we may note two scars on the central bowl, which are visible in fig. 1 as dark lines near the lower edge. One is close to the rim, the other about one sixth of a diameter above it. Since the handles allowed the shield to be carried either way up, these scars could have been made by slashing blows directed either at the top or the bottom.

Inside the covering there are fragments of timber (figs. 2-3 and 4), which have been identified as poplar.[16] The orientation of these has been somewhat distorted by shrinkage, which seems from the alteration in curvature to have been of the order of 25 %, and some of the fragments, particularly those lining the rim at the top of the picture, have

[14] Lysias, XII, 4.
[15] *Art. cit.*, p. 117, fig. 10.
[16] Rieth, *art. cit.*, pp. 104-105.

been replaced incorrectly. It is likely that originally all the timber of the main bowl lay with its grain aligned horizontally, parallel with the forearm holding the shield. However, Rieth's suggestion that the bowl was carved from a single block, which would have to have been 82 cm wide, cannot be supported. Many of the fragments show smooth edges running parallel to the grain and perpendicular to the front and rear surfaces of the shield. These are unlikely to have been formed by splitting, and are probably the edges of billets, some 20-30 cm wide, which were glued together to form the block. Rieth based his conjecture

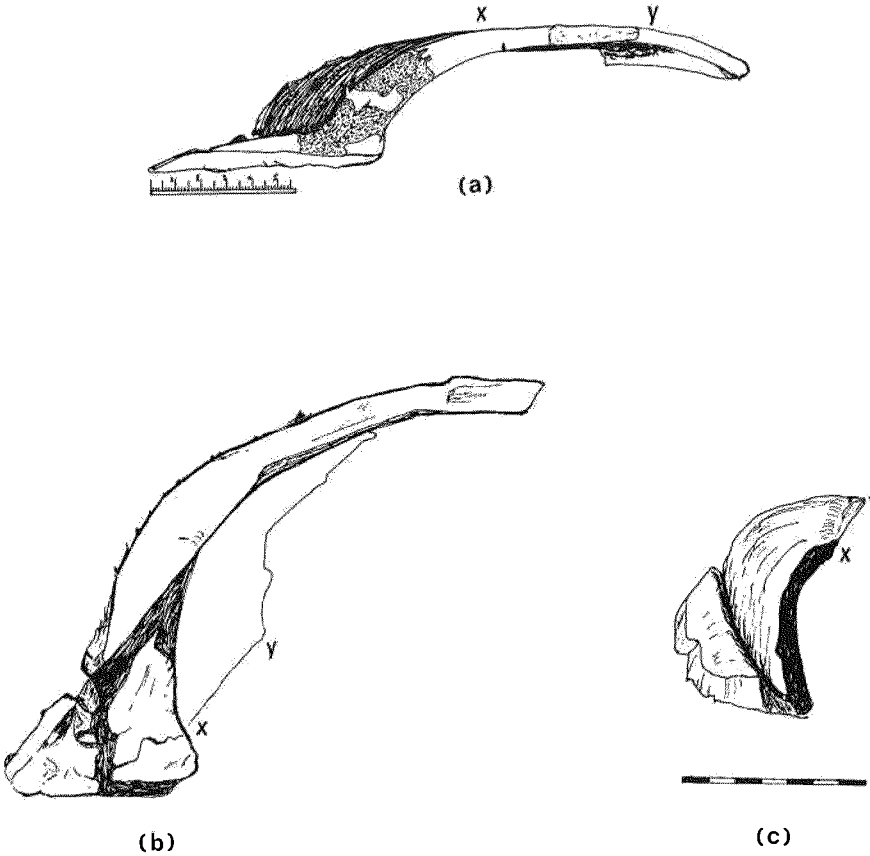

Fig. 4. Fragments of the timber core showing treatment of the edge and rim. In each piece the grain runs parallel with the edge marked *x-y*. In (a) the rim is thin, to leave room for the gluing on og reinforcements, whereas in (b) and (c) it is thick, but portions have split off along the grain. In (a) the plane surface parallel with the edge *x-y* seems to have been made deliberately, and a patch of glue is visible. Whether or not the glue is ancient, the surface was probably dart of a glued butt-joint, and shows that the shield was constructed of several pieces. Pitch is also visible, on the convex side of the fragment.

on the absence of any trace of the glue, and it may be that the substance now visible on the face of a fragment shown in fig. 4 (a) is recent, but glue must have been used to fasten the laths to the rim, as will be described below, and as it has disappeared there it can have done so elsewhere. However, there is no trace of lamination (the gluing of one layer of timber across another to minimise splitting), except in the rim, where that runs across the grain of the main core. Fig. 3 shows laths some 3 mm thick still in position. These were originally glued to the outer face of the main timber rim, which has shrunk away from them. (The piece of wood projecting from the rim at the left hand side of the picture is not in its original position). Figure 5 shows the arrangement schematically, and fig. 4 shows how the core was trimmed

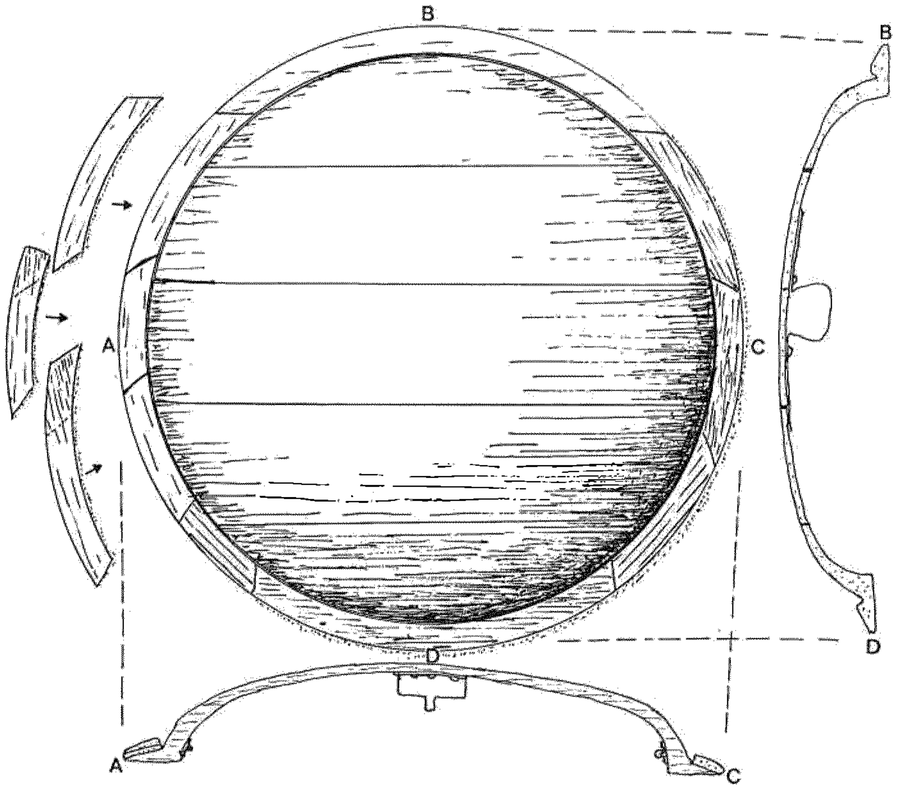

Fig. 5. The reinforcement of the rim. The convex side of the bowl is shown, with two cross-sections, to demonstrate the principle on which the reinforcement of the rim is arranged. The grain of the timber runs horizontally across the bowl. (The long horizontal lines, indicating the edges of the billets from which the original block is thought to have been formed, are schematic only and do not represent the actual position of the edges. The same is true of the lines marking the ends of the reinforcing pieces).

to make room for the laths where necessary. Fig. 4 also shows the fragility of the rim where it was not reinforced — i.e. where the rim ran parallel with the grain of the core — and the groove between the rim and the bowl underlying that already noted in the metal covering. It is clear that the purpose of the lamination was not to strengthen the rim itself against breaking off, since that is left unreinforced where it is most vulnerable, and it is further weakened by the groove; rather the intention must be to guard against splitting in the main core by binding together the fibres at each end. It may be that the same concern accounts for the groove also, if the intention was to tighten the cover around the rim by pushing the bronze down into it.

Fig. 4 also provides a view of the cross-section of the timber near the edge of the bowl and the rim. The sides of the bowl have a thickness of 10-14 mm, increasing towards the rim; however the inner portions are much thinner, and are today only about 5-6 mm thick. Towards the centre of the bowl the thickness increases again in some places, to around 8 mm. Assuming that shrinkage has been roughly uniform, the original thickness may have been greater by up to one third, i.e. 7-9 mm over much of the bowl, 10-11 mm near the arm-band, and 12-18 mm in the walls.

Where the original surface of the timber can be seen, it is mostly smooth, but at one point (near the left hand end of the largest fragment in fig. 3), there are circumferential scratches along the inside wall of the bowl. These would be consistent with the use of a lathe, as is suggested by the comic compound in Aristophanes[17] τορνευτο λυρασπιδο πηγός. Alternatively, perhaps, the shield could have been formed by a rotating tool, pivoting at the centre. Whatever the method, the bowl was being carved so thin that careful control was needed, and that is made easier by its circular shape which allows some form of rotary motion.

The outer surface of the timber is covered with a resinous substance, probably pitch. This would serve to bind on the bronze covering, but it may also have been traditional, as a survival from the practice of embossing designs on the bronze. The inner surface of the timber was covered with a very thin layer of leather, attached by glue, traces of which survive and still hold the leather in some places. The leather is much too thin to add protection, and is presumably decorative. It has been carefully cut and stitched to fit the bowl and the rim, and the edge runs underneath the bronze.

The closest parallel to this structure—which implies a method

[17] *Aves*, 491.

of manufacture not unlike that used today for the production of wooden fruit-bowls—is provided by the horizontal marks inside a shield-cover at Olympia,[18] which show the core to have been made from billets between 3.6 and 5.1 cm wide. However Kunze has also found traces of a quite different structure, consisting of a composite framework,[19] and at Olynthus[20] charred fragments of wood were found inside a hoplite shield which seemed to imply the use of lamination. Different structures may have resulted from the preferences of different workshops, but some indication of development may possibly be gained from changes in the profile. It would seem likely that a very deep profile, like that observable on some Attic Red Figure vases, implies the use of a framework. The extra depth could be obtained at very little extra cost, and would be needed to provide stiffness. A medium profile, like that of the present shield, can be carved from a solid block which is not too thick, and is yet deep enough and stiff enough to avoid bending or splitting. A laminated structure, finally, would allow a shallower profile, because it would not be in danger of splitting and could therefore be a little more flexible, and it would also be easier to make in a shallow curve, because of the need to apply pressure in gluing. On these grounds, the solid shield would seem to have been the most popular down to the early Vth century; it may then have given way increasingly, especially in Athens, to the framework, and the laminate may have come in the IVth century. However only the solid version would seem to benefit from a circular shape, as far as manufacture is concerned, and inferences might also be drawn from the occurrence of other shapes, notably the Boeotian, which must have used a framework, and the oval. (Further remarks on the laminated shield will be made towards the end of the paper). For the thickness, we may compare the 6-7 mm found in the wooden laminations of the much later Roman *scuta* found at Doura Europos; these may have shrunk to much the same extent as the present shield, and may have had a substantial covering of leather.[21]

For the use of poplar as a shield timber we have the evidence of Pliny:[22] *Frigidissimum quaecumque aquatica, lentissima autem et scutis fa-*

[18] KUNZE, *Ol. Ber.* V, p. 64.

[19] KUNZE, *Ol. Ber.* III, p. 81.

[20] D.M. ROBINSON, *Olynthos* X, p. 443 ff., plate 135; G.E. MYLONAS, *AJA* 43 (1939), p. 57. However the evidence as it is presented does not show conclusively that the charred timbers found must have been laid across each other. The shield did not have a full bronze cover, only a covering for the rim.

[21] F. CUMONT, *Fouilles de Doura Europos* (Paris 1926), pp. 261-263.

[22] *N.H.*, XVI, 209.

ciendis aptissima quorum plaga contrahit se protinus cluditque suum vulnus et ob id contumacius transmittit ferrum, in quo sunt genere ficus, vitex, salix, tilia, betulus, sabucus, populus utraque. Levissimae ex his ficus, vitex, salix, ideoque utilissimae. This suggests that poplar may have been less favoured than willow, and it may have been a cheaper substitute, especially in Italy where poplars are common. The two timbers are very similar, both being long-fibred hardwoods with a high resistance to splitting, and Pliny is wrong to suggest a difference in weight, but the advantage of willow, which appears in the solid timber as well as in the twigs, is that it is *lenta*; it has a low elastic modulus and will sustain an unusually large amount of deformation without fracture.[23]

Comment

This shield was certainly made as a practical weapon, not as a funeral decoration. There is little sign of use in battle, unless the horizontal scars were made by slashing blows, but the absence of embossed decoration, the careful reinforcement of the rim, the strength with which the handles are attached, and the choice of timber, all tell in that direction. Moreover, the skill with which the timber has been shaped, the care taken to adjust the thickness and control it over the cross-section, the neat fitting of the leather lining, and still more that of the bronze covering, all indicate experience which must have been built up in a long tradition—and must have commanded a high price. Livy [24] tells us that only the richest of the Servian classes carried the *clipeus*, the remainder carrying the *scutum*.

At the same time, the method of construction is not one which

[23] G.M. Lavers, *The Strength properties of timbers* (Ministry of Technology, Forest Products Research, Bulletin 50², 1969) gives the following figures. Specific Gravity: Black Poplar 0.38, Grey Poplar (Populus canescens) 0.43, Willow (Salix viridis) 0.38. Both poplars are considerably stiffer and stronger than willow—in fact in those properties they are hardly inferior to Spruce or Silver Fir, whose weight is similar. In resistance to splitting both Willow and Grey Poplar have about 80% of the strength of Oak, and about two-thirds of the strength of Wych Elm, the very tough timber used for wheel-hubs; in comparison with their weight they do better than the former and about as well as the latter. Black Poplar splits rather more easily, but is still about 30% better than any soft-wood except Pine. However, in the figures for the absorbtion of energy in bending to maximum load, both Willow and Poplar are about twice as good as any soft-wood except Larch (which, however splits more easily, and is heavier), and weight for weight they are superior to any other hardwood given, Willow being slightly the better. This parameter is probably as close as can be obtained to what Pliny means by *lenta*, and the figures corroborate his observations, though not of course his explanation. In fact fig-trees and vines (for which no tests are available) are not aquatic, and though Birch, which does like a damp soil, does well, the next best timber after Poplar and Willow is Red Oak, followed by Turkey Oak (Ilex), neither of which is aquatic, and which Pliny ignores.

[24] I, 43.

would recommend itself to someone designing a shield *ab initio*, but looks like a marriage between two quite different traditions. On the one hand the shape and the fittings are quite clearly derived from the Greek *aspis*, which itself seems to have been derived from a Cypriot version in wicker whose ancestor was probably the round wicker shield of the Assyrian heavy infantry. This line of descent was proposed by Lippold,[25] partly because he thought that the round shape was functionally disadvantageous, and could only be explained by an origin in some material such as wicker in which (he thought) circles are easier to produce than oblongs, and partly because the guilloche pattern, which traditionally decorated the rim in the Greek version, first appears in Cyprus. The first of these arguments is doubly invalid: basket-makers produce oblongs just as readily as circles, and the circular form needs no special explanation because it is the natural shape for a buckler —that is for any type of shield which will be raised and lowered rapidly in parrying an opponent's blows, and so tend to rotate as the forearm pivots at the elbow; the shape is found in many materials all over the world, and all that is unusual in the Greek version is its large size, which has made Lippold think of it as a static covering for the body. Indeed, if the shape were not itself advantageous in some way, its persistence for several centuries and despite a radical change of material would be hard to explain. However, the second argument is strong, and can be taken further; the prevalence of the guilloche pattern on the rim, over all other motifs, is very striking, and looks like a reminiscence of a woven rim, which would make very good sense on a wicker shield. As we shall see, the projecting rim which is characteristic of the *aspis* does perform a useful function even in the wooden version, but it may quite well be that once the transition was made from wicker (where distortion quickly reveals the pattern of stress) that function was no longer understood, that the Greeks then covered the rim with decoration as some sort of excuse for continuing it, and that the Etruscans omitted the decoration, but still kept the rim without question. This conjecture is supported by an oddity in the arm-grip which seems to derive from a similar sequence. In the Etruscan version, the arm-grip has flanges which extend beyond the rivets attaching it to the timber, for about 15 cm. These flanges can serve no useful purpose, since all the strenght necessary is supplied by the rivets, while the cemented joint for which they provide cannot have been very strong. They are thus undecorated analogues of the often very strikingly

[25] *Die Griechische Schilde*, in *Münchener Archaeologische Studien dem Andenken Adolf Furtwängler gewidmet* (Munich 1909), pp. 445-6.

decorated extensions of the arm-band found in Greece, which also have no structural role (and are often very thin, and sometimes quite detached from the main flange, which carries the rivets).[26] It is difficult to see any other origin for these than in a wicker shield, where long flanges would be needed to spread the load, and rivets could not be used. Once again decoration is used to justify the survival—or conversely the loss of function provides an opportunity for decoration—and even the style of the decoration may recall the origin, since the typical pattern is produced by dividing the flanges into a series of panels each taking up the whole width of the flange, and arranged one above the other, as if at intervals the original flange was crossed by a fastening whose ends were woven into the wicker of the shield-bowl. Finally, the cross-sectional profile of the shield is one which is easily formed in wicker, rather less easily in leather, and only formed with considerable difficulty and waste of material in solid timber.

On the other hand, the way in which the timber is handled is reminiscent of the flat shield made of boards, which occurs frequently in northern Europe, especially in Celtic areas. There is the same confidence in a simple butt-joint, and the timber runs right across the shield in what were once thick billets; the bowl has not been built up as a mosaic. It is as if traditional makers of wooden shields have undertaken an alien shape without fully understanding it, but doing their best to render it practical in their own terms, and rejecting unnecessary frills.

We do not know where these two traditions were first married; the present example is clearly provincial, and in itself tells us nothing about its Greek ancestors in timber (though it does show how difficult the problem of making the shape was). However, as we have seen, it is unlikely that the Etruscans made the change themselves, and more probable that it originated in Greece, at a time when interest in the use of the lathe provided a further stimulus. So its functional properties may be quite a good guide to what a Greek, as well as an Etruscan, expected from a hoplite shield, and hence, to the manner in which he used it.

In the first place, it seems that the shield was expected to be very light for its overall size. The weight of the present example in its original state may have been approximately as follows:

Bronze sheathing	about kg.	3.0	
Timber core	»	2.5	
Leather lining arm-band & handgrips	»	0.2	
Bronze fittings for these	»	0.5	
Total		6.2	(13.5lb).

[26] KUNZE, *Ol. Ber.* I, p. 54 ff.

The total is little more than the weight of a World War II rifle, a weapon which can be handled quite briskly by a trained man, and portrayals of hoplites in action on red-figure vases suggest that the shield could be used with rapid movements to parry a blow—at any rate in the fifth century. Anything much heavier than this would have

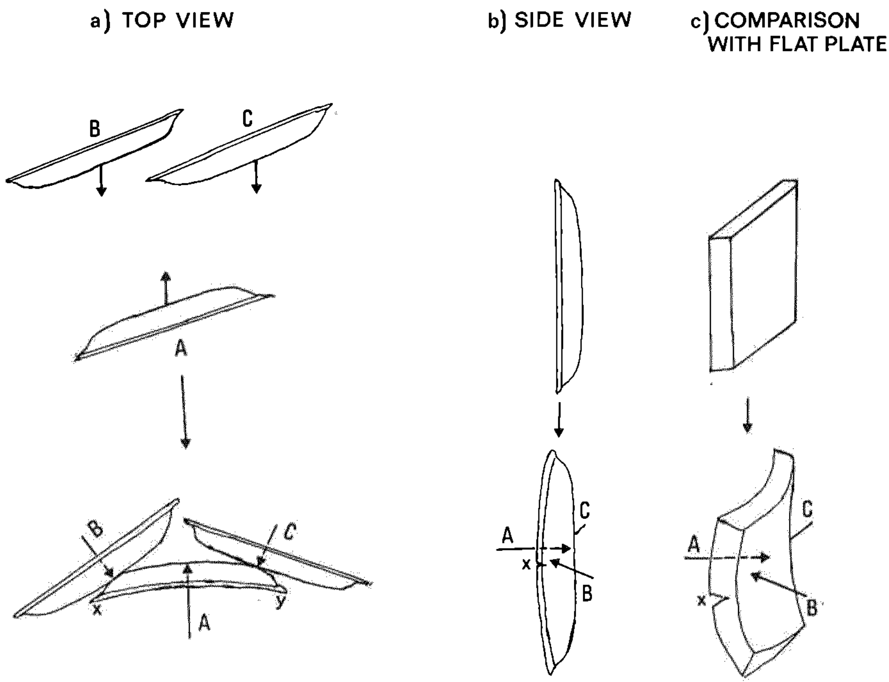

Fig. 6. The bending of a shield in a melée. The warrior A is charging two others, B and C, and his shield bends under the impact. If the grain in the timber of the shield runs horizontally, the bending in that plane (shown in a) is not dangerous, but the anticlastic bending in the vertical plane, which is shown in b and diagrammatically in c, could cause cracks at x and y if the rim were not reinforced there.

been hard to handle in that way. Even as it was, the *aspis* in Greece had to face competition later in the century from the lighter *pelte*, though in Italy development went the other way, towards the heavier *scutum*, for reasons which will be briefly touched on further.

Secondly, the hoplite was prepared to pay for this lightness in a large shield by accepting a considerable risk of penetration. The bronze sheathing contributes little to the protection, since it has about half of the minimum thickness used for plate armour (which is hardly ever less than 0.7 mm, and usually around 1 mm to 1.2 mm). Since resistance to penetration in thin metal varies in proportion to the square of the thickness, the sheathing thus gives about half the protection of the thinnest armour and one quarter of that in most Etruscan helmets. Since the leather lining is likewise too thin to make a serious contribution, most of the protection must come from the timber core, and over much of the area, especially in the centre, which would seem to be the most important, the core cannot have been more than 8 mm thick, and may have been less. That would give a protection comparable to that of a single layer of hide, and weighs about the same amount per unit area. (We may note in passing that each would weigh only about half as much as the additional bronze which would be required if that material were being used to provide the resistance to perforation). The adequacy of that would depend very much on the size of the opposing weapons, because the work of perforation in both leather and timber is proportional to the square of the diameter of the projectile. The present shield should keep out a normal spearhead, but it could be penetrated by a weapon with a diameter of about 1 cm and an energy of about 30 Joules—conditions which are fairly easily met by a heavy arrow or a slim javelin. Literary and pictorial evidence suggests that Greek hoplites too accepted a comparable risk in the 5th century. In the Sosias cup [27] Patroclus has been wounded in his shield arm, probably by the arrow which is shown behind him and which may have passed through the shield on which he is now sitting. There is a picture of an arrow passing through a shield on a red figure *kylix* in the Agora Museum in Athens.[28] Brasidas is said to have been wounded by a javelin which passed through his shield,[29] and Xenophon records penetration of shields by the arrows of the Cherusci.[30] It is also possible that the casualties sustained by the Spartans at Plataea before they could charge the Persians were caused by arrows coming through the shields behind which they crouched.[31]

Thirdly, both the shape and the method of construction emphasize the great importance attached to rigidity, and indeed show that this concern was a major determinant in the evolution of the design. As we have seen, the shape derives from a wicker original which must

[27] Berlin, F 2278, ARV 21.

[28] P2411, *Kylix* by Gorgos. Penetration of shields and armour is a favourite theme of Chalcidic painters, though their portrayals are not always convincing. E.g. Orvieto, Museo dell'Opera del Duomo, 192 (Rumpf 151), and Tarquinia Mus. R.C. 5655 (Rumpf 152), both showing spears penetrating shields, and Leningrad, Hermitage no. 1479, showing Penthesilea's arrow penetrating Achilles' shield.

[29] Plutarch, *Moralia*, 190 B.

[30] *Anabasis* IV, 1 & 2.

[31] Herodotus, IX, 72.

already have had a central arm-band and a broad rim, and the construction of the present shield shows that the rim was not put there in order to catch blows delivered near the edge of the shield; if it had been, it would have been necessary to reinforce it where the grain runs parallel with the rim and makes it possible for portions to be split off by a heavy blow. The purpose of the rim is therefore structural, and while in the wooden type it has a secondary advantage in providing a surface onto which to glue reinforcements to prevent splitting, its main function, especially in the wicker original, must be to stiffen the bowl, by forming a flange which prevents the sides from buckling. This effect can conveniently be seen in the flanged lids which are fitted into the tops of small metal cans,—for example those which hold paint, or cocoa powder. If we take such lids and cut off from some of them the flange, and from some also the vertical sides, measuring the resistance to bending in each configuration, we shall typically find that while the sides and flange together account for about half the weight of the lid, the sides increase the bending strength by a factor of about 5, and the sides and flange together increase it by a factor of about 10, so that the addition of the flange has about doubled the resistance to bending. Without the flange, the sides of the lid tend to buckle, moving outwards along the axis of the bending and inwards along the other axis; the function of the flange is to prevent this distortion by maintaining its circular shape, and it follows that its effectiveness depends upon its stiffness in the horizontal plane. Thus a wide rim will be more effective than a narrow one, even if the latter is thicker and contains the same amount of material. Since both the projecting rim and the central arm-band can, as we have seen, be traced back to the wicker version, it is reasonable to suppose that they are directly related to each other; that the opportunity furnished by the arm-band to throw the full momentum of the body behind the shield could only be taken if the shield could be prevented from bending catastrophically if it happened to be thrust between those of two opponents. Even with this reinforcement, wicker was probably still too soft, and its replacement by a stiffer material would be a natural evolution, though considerations of weight did not allow the protection in the centre to be seriously increased.

Whether the full elaboration of the rim remained necessary in the new material, only tests with a full-scale model could tell. Tentatively I should suggest that it did, at least until the principles and practice of lamination were better understood. Although the edges of the shield have been reinforced where they cross the grain, the reinforcements are placed on the front of the rim and not on the back, where it seems likely that the greatest strains would arise. Tough as willow is, the maximum strain tolerable across the grain must be well under 0.1 %, which means that distortions causing bending of the rim to a deflection of even a few millimetres could cause serious trouble. A very broad guess, based on the assumption that the shield would, like the metal lids, be about ten times as stiff as a flat plate of the thickness found in its centre, suggests that it would stand up well to static pushing and shoving in a melée, but that a serious crack could be started in the rim as the result of a combination of dynamic loading by the momentum of the warrior's body and an awkward impact; for example, if a vigorous charge ended in a deceleration of the body at a rate of about 4 G when the shield met those of two opponents which struck it one on each side near the edge as shown in fig. 6.[32] Such a circumstance would also be just about sufficient to damage one of the Doura Europos shields, which are much less stiff, but also allow much greater deflection. In each case we may observe that the outer covering, the bronze in the *clipeus* and the leather in the *scutum*, would prevent complete collapse. The shield would have to be replaced later, but it would last out the battle. Bearing in mind the requirement for light weight, a strength sufficient for general use but leaving the exceptional case to be covered by a ' fail safe ' reserve, is very much what we should expect in a practical weapon which had evolved over a considerable period. (It may also account for the fact that the earliest Greek *aspides* had a bronze cover only for the rim, leaving the centre bare). Conversely, the strength of the present shield may fairly be taken as evidence that such dynamic loads were occasionally imposed.

All three of these aspects of the shield thus combine to give us a picture of a warrior who is concerned to close with his enemy quickly. The shield is light, to allow him to wield it rapidly, and to run. It does not offer fully adequate protection against missiles—he is expected to get in before many can be thrown. It is stiff enough to allow him to charge. The picture is somewhat different from the conventional accounts we are often given of ' heavy infantry ', but quite recognisable from Xenophon's Anabasis and Cyropaedia. But did the owner get value for money, supposing that there were already *scuta* available and being purchased by the lower classes? The examples from Doura Europos are clearly better weapons than this *clipeus* because they are no heavier but provide more protection; since the wooden structure

[32] The calculation is based on data for the elasticity and resistance to splitting in Willow given by the reference in note 23, and assumes that the loads on the sides are fairly concentrated at points on the horizontal diameter near the edge of the shield.

is laminated it does not need to waste weight in reinforcements, and can be covered with a thick layer of leather. But the Doura Europos examples are many centuries later, and earlier models may have been heavy and crude beside the *clipeus*. Also, the upper class may have preferred the *clipeus* because it allowed a more elegant style of fighting, as well as for its associations. But what must have doomed it, apart from its cost, must eventually have been its ineffectiveness against javelins, and that is probably why, before going out altogether, it was relegated to the rear ranks.