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With only two tools—compass and straightedge—the forms of the Monasterevin-type discs can be replicated. In every case, a straightforward, continuous process of designing will produce a form in which all the principal measures among the circles and arcs combine in a disciplined harmony of proportion. In this respect they all show the same 'coherent geometry' that distinguishes the much later designs of early Irish high crosses, 'carpet' pages in the fine Insular Gospels, the Tara and Hunterston brooches, as well as even earlier metalwork in the same tradition. This paper narrates procedures, employing only those two tools, for drawing plans of all the known discs, reviews in detail the correspondence of each artefact to its geometrical model and attempts to epitomise the essential features of the forms of these discs.

'Monasterevin-type' is a conventional denomination for seven bronze discs that have been grouped together for design features which they all share, uniquely. This is appropriate, strictly speaking, for the five whose find-place is unrecorded, reserving 'Monasterevin discs' for the two found in the vicinity of Monasterevin, Co. Kildare.[1] For the main text of this paper, though, I will simplify this, using 'Monasterevin disc' as the general term for any and all of the surviving discs. Six of these discs (Fig. 1) are now in the National Museum of Ireland, one (Fig. 8) in the British Museum. All are large, in the range of eleven inches in diameter. All have been hammered into relief from the reverse side (by repoussé), with curvilinear ornament in the La Tène style. They are dated conventionally by style, to somewhere in the first two centuries A.D. The forms of these Monasterevin discs have been analysed impressionistically—for what they seem to look like, what they may have meant, what they may have been used for Yet these forms, intriguing as they are, have not been examined for how they may have been devised, and for what the nature of those forms is, analytically.

It takes only two tools—compass and straightedge—to replicate the forms of the Monasterevin discs. In every case, a straightforward, continuous process of designing will produce a form in which all the principal measures among the circles and arcs combine in a disciplined harmony of proportion. In this respect they all show the same 'coherent geometry' that distinguishes the much later designs of early Irish high crosses, 'carpet' pages in the fine Insular Gospels, the Tara and Hunterston brooches, as well as even earlier metalwork in the same tradition. That is the first item—their coherent geometry—that I should like to add to the inventory of traits shared by all the surviving discs, traits which define the type of design now carrying a common name.

Other traits are familiar. They have been described this way by Professor Barry Raftery: 'A feature common to all the discs is a plain, eccentrically-placed circular area defined in every case by a raised ring of rounded section.' They all have paired snail-shell spirals. And so on. Beyond that, however, it can only be said that 'The patterns on the discs resemble each other closely, but in no two cases are the designs identical'.[2]

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Fig. 1 The six Monasterevin-type discs in the National Museum of Ireland: a NMI W.3, b NMI W.4, c NMI W.5, d NMI W.6, e NMI W.1, f NMI W.2.
Photos: National Museum of Ireland.

Learning how to replicate these forms is a way to recover their coherent geometry, and it enables us to add still more to the inventory of traits shared by some or all of the particular pieces. When these forms have been analysed we may understand their designs better, even if not their purpose.

REPLICATING THE DISCS' FORMS

This section will describe procedures employing only compass and straightedge for drawing plans for all the known discs. The narratives of procedures could be abridged if the procedures could also be shown in action, rather than as static drawings. And each narrative could be reduced to a few remarks and gestures or sketches if it were communication between master and apprentice, both already conversant with the methods and rules of the tradition in which the designs were created. Failing these circumstances, the narratives must work their way laboriously through the procedures (it may seem) in order to be clear and complete. There is no shortcut to understanding this tradition in designing. But the way will be shortened and much enlivened, if a reader re-enacts the procedures a pair of compasses in hand.

Begin with steps to replicate features common to all the known examples. See Fig. 2.

2.1 All are circular discs (or fragments of them), so we begin by setting the fixed point of the compass and describing a circle (1).

All have bilateral symmetry, so we next draw a line through the centre (2)—a diameter that divides the circle equally in two parts.

All the discs seem to depend on setting a second diameter perpendicular to the first (3), dividing the disc equally into four parts. The compass work for this is elementary. The result is a covert element in the designs: it appears in neither the symmetry of the form, which is bilateral only, nor the placement of the cores of the paired spirals, yet it will inform construction of the designs in crucial ways, as will appear presently.

2.2 All have paired circular areas from which arise spiral patterns, as is obvious by inspection; not obvious by inspection is the fact that all the centres of these areas are located along lines radiating from the centre of the disc to two points that mark one-third of the circumferences. So we set the fixed point of the compass at one end of the vertical diameter, and with the compass set equal to the radius of the circle, mark those two points on that circle (4), and then draw radii to the points just marked (5).

A line between these points cuts the radius into two equal parts (6).

From there on, the procedures of constructions also 'resemble each other closely, but in no two cases are the designs identical'; the resulting schemes of geometric harmony will be similar, with no two being the same.

In describing these forms, and the construction of them, it is natural to use terms such as 'top', 'lower', 'above', 'below'. The common orientation puts the large paired spiral devices in the upper area of the discs, where they have been anthropomorphised into 'eyes', with arcs above them seen as 'eyebrows', the whole design seen as resembling 'a grotesque face'.[3] For convenience, the orientation frequently used in recently published photographs and drawings will be employed here, though without interpretation anthropomorphic or otherwise. It may be noted, however, that the earliest publication of these discs had an orientation the inverse of what is now common.[4]

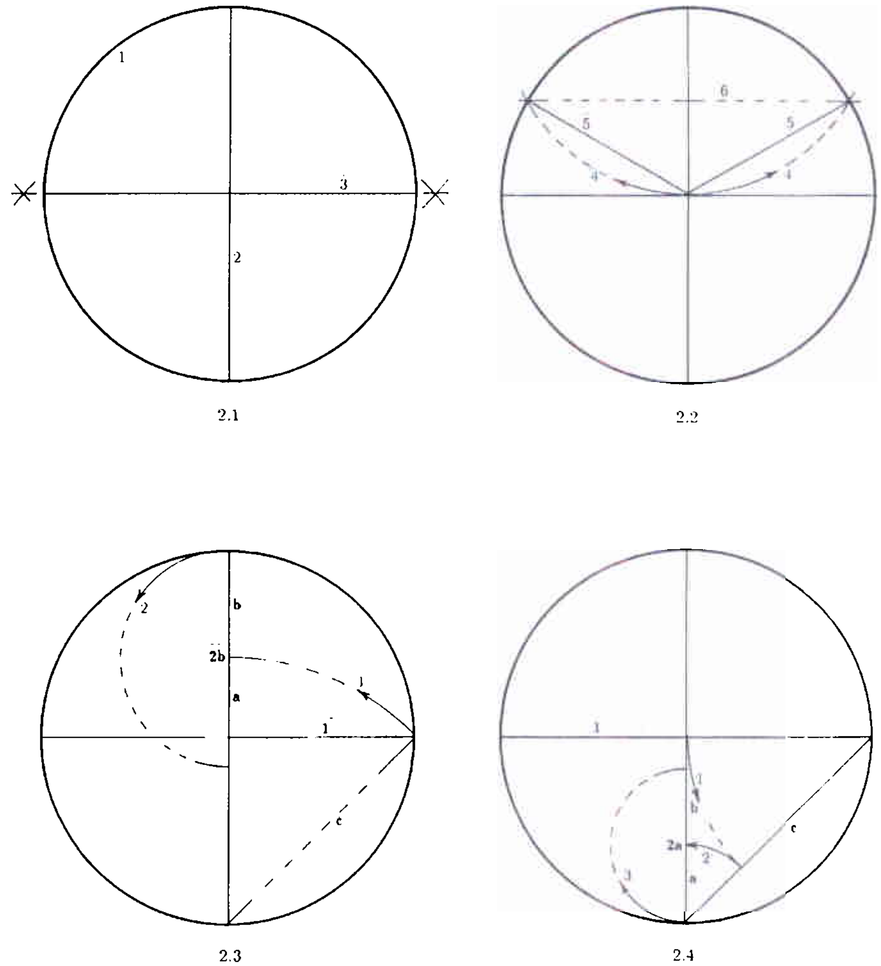

Fig. 2 Initial steps in devising the forms of all Monasterevin-type discs (2.1-2), and alternate procedures for locating centres for the eccentric circular area in five of the seven discs (2.3-4).

The next trait is shared among five of the seven discs: NMI W.1, NMI W.3, NMI W.4, NMI W.5, NMI W.6. It is the location of the centre of the 'eccentrically-placed, circular area'. These circular areas, even as the discs themselves, vary in size, independently. Their centres, on the other hand, are invariable in relation to the disc outline. Two convenient ways to locate these centres are illustrated in Fig. 2.3-4.

2.3 One way is to set the fixed foot of the compass at one end of the vertical diameter, take the measure *c*—the chord of a quadrant—and mark it along the diameter (1). That leaves a complementary measure *b* along the diameter. Then copy *b* along the diameter, in effect doubling it (2).

2.4 The other way is to sketch the chord of a quadrant (c), as shown, copy the circle's radius measure along it (1), and then copy the remaining measure a along the vertical diameter (2); then double measure a along that diameter (3).

The result is the same with either method. It locates the centre for the eccentric circular area at a point along the axis of symmetry that has a simple proportional relation to the measure (the diameter) of the enclosing circle. That relation can be seen, and it can be sensed in a tactile manner by following its unfolding in operational terms. It also can be expressed in modern notation: if the radius length is stipulated as 1 (diameter as 2), the locus of the centre is $2b$ from the top, and it is $2a$ from the bottom. Now, consider the derivation in terms of its geometry: radii at right angles are the sides of a right triangle, sides =1; the hypotenuse of that triangle—the chord c of that quadrant—is therefore $2-\sqrt{2}$, by the Pythagorean theorem. Thus, in Fig. 2.3 the length of b is

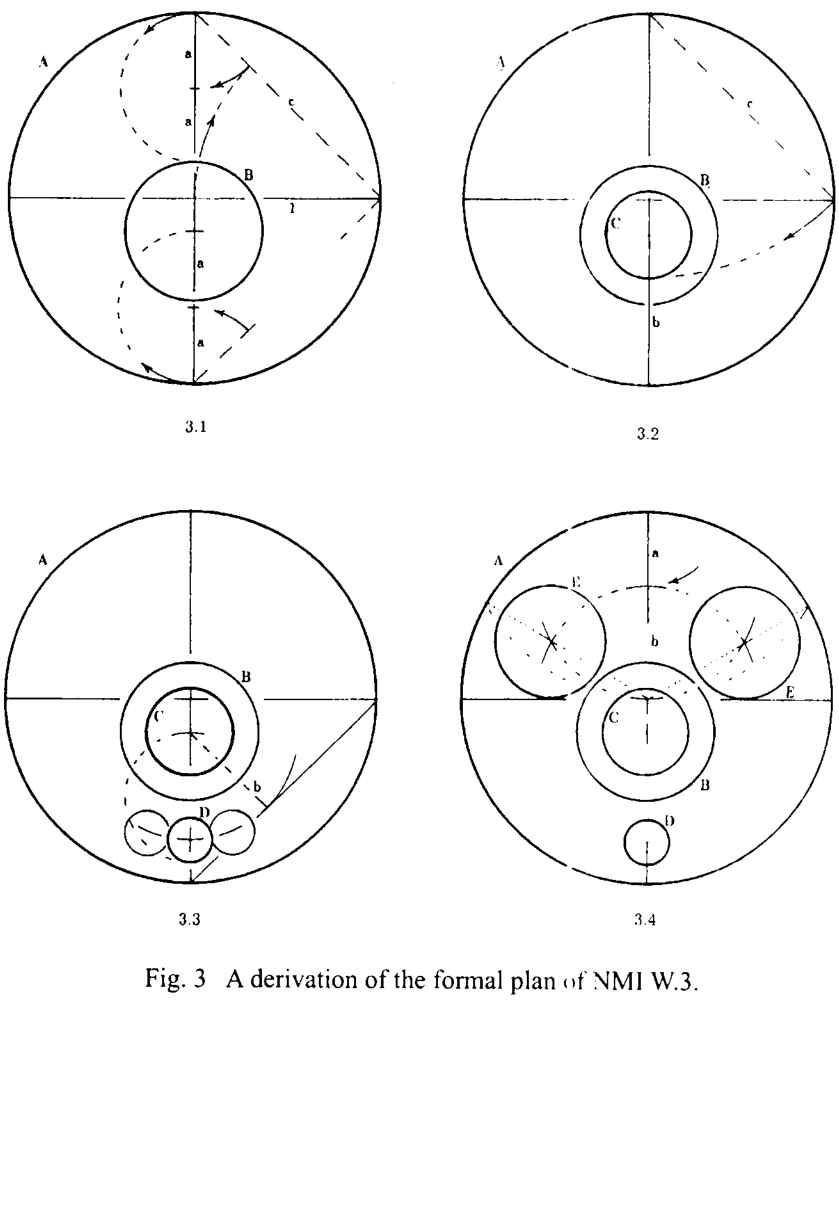

Fig. 3 A derivation of the formal plan of NMI W.3.

2-Ö2, and the length a is $\sqrt{2}-1$. Or, in Fig. 2.3 the measure a is $1-b$, and in Fig. 2.4 the measure b is $1-a$. This modern notation will be useful in displaying the coherence of relations among measures throughout all of the discs' designs.

For these five discs, the centre of the inner circular area is also (so to speak) central to the whole harmony of proportion in each design. The best way to explicate this is to show step by step how to replicate one of the designs.

NMI W.3 Described next is a derivation of the form of disc NMI W.3, one of the two whose find-place lends its name to all these artefacts.[5] See Fig. 3.

Circle A. 3.1 This is the outlining circle, with its central axis and division into equal thirds and fourths (as in Fig. 2.2).

Circle B. 3.1 From the bottom of the plan, mark length a along the vertical diameter, then double it (as in Fig. 2.4) to locate the centre of circle *B*. Then from the top of the plan, mark length a along the vertical diameter, and double it to locate a point on the circumference of circle *B*. Draw circle *B*.

The harmony of proportion thus starts with iteration of $2a$, once to locate the centre and once to set the radius of the eccentric inner circle.

Circle C. 3.2 Copy the measure c from the top of the plan along the vertical axis to locate a point on the circumference of circle *C*. Centre of circle *C* is the same as the centre of circle *B*. Draw circle *C*.

Circle D. 3.3 From the centre of circles *B/C* copy the measure b below along the vertical diameter to locate the centre of circle *D*. (A derivation of measure b in place, as shown, is simple to execute, less simple to spell out.) Then copy the radius of circle *B* below its lowest point—i.e., double the radius below the centre—to locate a point on the circumference of circle *D*. Draw circle *D*.

This gives iteration of the diameter measure of circle *B* and the measure from its centre to the lower extent of circle *D*. Further iteration can be traced through recurrences of measure b, and in the listing of measures in Table 1.

Circles E. 3.4 Points marked on the circle *A* dividing it into thirds were set in Fig. 3.1 (same as in Fig. 2.2). Sketch radii of circle *A* to these points just marked (10 o'clock and 2 o'clock positions): where these intersect an arc concentric with circle *A*, with radial measure b, will be the centres of circles *E*. (This procedure also lays down lines useful for locating the centres of the curvilinear devices just inside the perimeter of the plan.)

An alternate method is this (the designer may well have used both methods). From the centre of circle *A* sketch an arc in the upper half having radius with measure b ; from the point where that arc intersects the vertical axis, sketch another arc also having radius with measure b: where these two arcs intersect will be the centres of the pair of circles *E*.

Draw the pair of circles *E* tangent to the (horizontal) midline of the plan.[6]

The centres of the spirals on either side of circle *D* (see Fig. 3.3) are along an arc with the same radius and centre that plots the centre of circle *D*.

Table 1 lists the principal measures within the plan, all expressed in terms of 1, 2, *a*, *b*, *c* ; these reduce to 1, 2, and $\sqrt{2}$ in their various elementary combinations: $c = \sqrt{2}$, $b = 2-\sqrt{2}$, $a = \sqrt{2}-1$.

Table 1. Dimensions of N. M. I. W.3 disc

Circle A.	Radius:	1
	Diameter:	2
Circle B.	Top:	2*a* from top of circle *A*
	Centre:	2*a* from bottom of circle *A*
Circle C.	Centre:	2*a* from bottom of circle *A*
	Bottom:	*c* from top of circle *A* or b from bottom of circle *A*
Circle D.	Centre:	*b* below centre of circles *B* and *C*; *b* is also the measure from centres of circles *B/C* to chord of lower quadrant of circle *A*.
	Bottom:	diameter of circle *B* below centre of circle *B*
Circle E.	Centre:	intersection of two arcs with radius *b*, one with centre at centre of circle *A*, the other with centre at *b* above centre of circle *A* (or, intersection of radius of ⅓ of circle *A* with arc having centre of circle *A* and radius *b*)
	Radius:	½*b* (its centre to (horizontal) midline of circle *A*)

For the five discs designed with a unique common trait, it may be helpful to use a common set of labelings of their parts and of their relational features. The ones in Fig. 3 will be used as well in Figs. 4-7.

- **A** identifies the outer circle,
- **B** identifies the outer eccentric circle,
- **C** identifies the inner eccentric circle,
- **D** idenfies the central (axial centred) lower circle,
- **E** identifies the 'eye-like' pair of circles.

And in these five analytic procedures, the measures are these:

- 1 represents radial measure of the disc,
- *c* represents the chord of a quadrant, which is $\sqrt{2}$ in relation to the radius,
- *a* represents *c*-1 (chord less radius),
- *b* represents radius less *a*, or diameter less *c*.

(For the two remaining discs these conventions will need to be modified).

NMI W.4 This is the other disc known to have been found in the vicinity of Monasterevin. Its form can be replicated with the same initial steps just described. See Fig. 4. This disc has some serious asymmetries, especially obvious in the arcs immediately surrounding the central circular form; the central circle is deformed, most noticeably in its flattened top and its spreading sides. The coherence of most of its underlying form is nonetheless recoverable.

Circle A. 4.1 As before, with division into halves, thirds, and fourths.

Circle B. 4.1 Same as in Fig. 3.1.

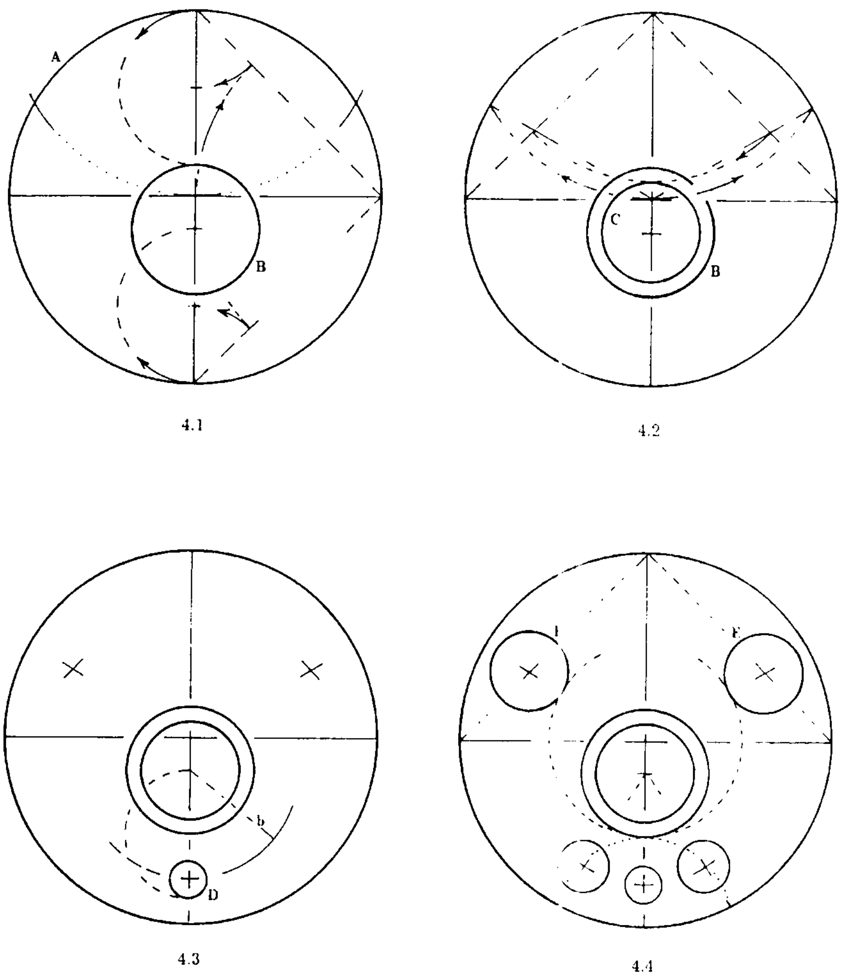

Fig. 4 A derivation of the formal plan of NMI W.4.

Circle C. 4.2 In the upper quadrants, mark intersections of chords of those quadrants with the radii (5) drawn in Fig. 2.2. (These will be the centres for the two circles *E*.) Take the measure from the top of the vertical axis to either of these intersections, and copy it along that axis, setting the radius measure for circle C, concentric with circle B.

Table 2. Dimensions of N. M. I. W.4 disc

Circle A.	Radius:	1
	Diameter:	2
Circle B.	Top:	$2a$ from top of circle A
	Centre:	$2a$ from bottom of circle A
Circle C.	Centre:	$2a$ from bottom of circle A
	Top:	(see the drawing)
Circle D.	Centre:	b below centre of circles B and C
	Bottom:	$2(1\text{-}2a)$ below bottom of circle B; or diameter of circle B below centre of circle B
Circle E.	Centre:	intersection of radius of one-third of circle A with chord of circle A in each upper quadrant.
	Radius:	(as shown)

Circle D. 4.3 Copy measure *b* below the centre of circles *B/C* to locate centre of circle *D* (same as Fig. 3.3). Copy the radial measure of circle *B* below that circle to set the radius measure for circle *D* (again same as Fig. 3.3).

Circles E. 4.4 Their centres lie at intersections of chords of upper quadrants with radii to the two points dividing the outer circle into thirds (as in 4.2). Take the measure from the centre of circle *A* to bottom of circle *B*, and mark it along the radii passing through the centres for these circles, setting their radius measures.

Also shown is the probable plotting of centres for the spiral devices flanking circle *D*. Table 2 lists the principal measures within the plan, all expressed in terms of 1, 2, *a*, *b* (derived from 1, 2, $\sqrt{2}$) in various elementary combinations.

NMI W.5 Although this disc is incomplete, most of its features are intact, so that its form can be reconstructed with little guesswork. Its being one of the two most perfectly produced pieces among the seven[7] makes recovery of its form the more valuable, in illustrating the thoroughness and precision of the coherent geometry of its form. In streamlined version, here is a derivation of its form. See Fig. 5.

Circle A. 5.1 As before, with its division into halves, thirds, and fourths.

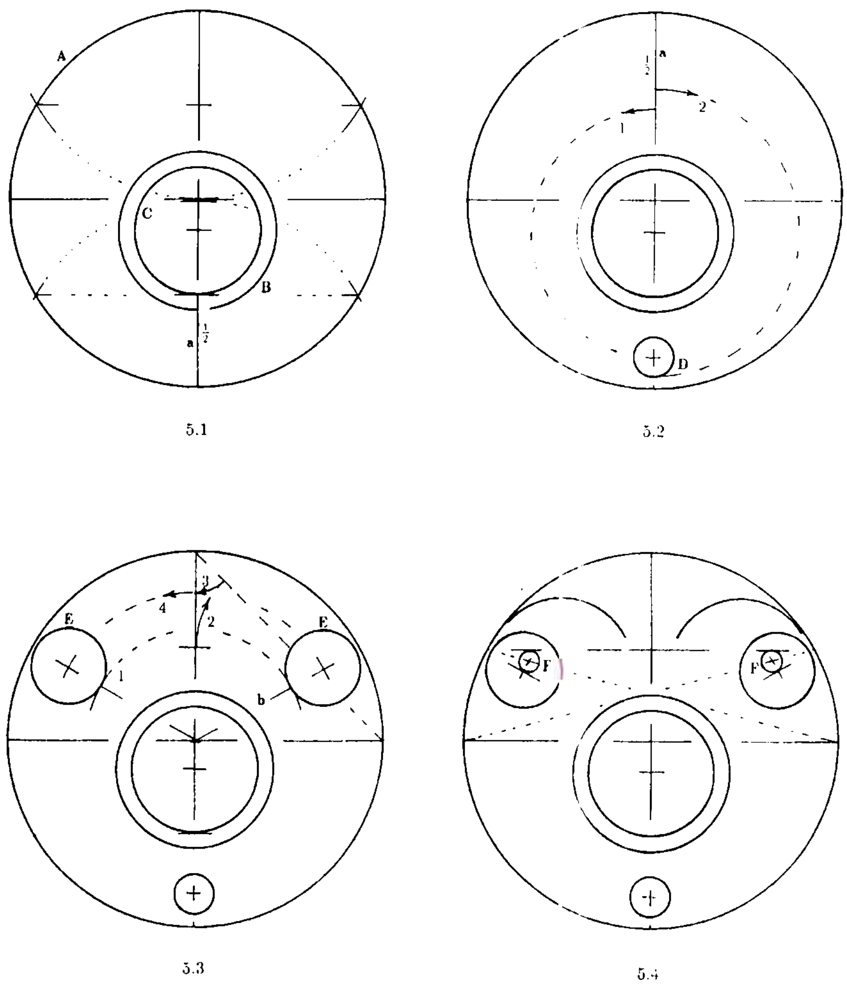

Fig. 5 A derivation of the formal plan of NMI W.5.

Circle B. 5.1 The centre of circle *B*, as in the two examples preceding, is at 2*a* above the bottom of form. The lower limit of its radius is measure *a* from the bottom of the form.

Circle C. 5.1 Mark ½ radius measure along the lower segment of the vertical axis (inverse of Fig. 2.2) to set the circumference of circle *C*. It is concentric with circle *B*.

Circle D. 5.2 This is entirely conjectural. *From the centre of circles B/C find the measure to the midpoint of the upper radius, and copy it (1) along the lower vertical axis to mark the centre. From the same centre find the measure to a point at distance a from the top of the form and copy* *it (2) to locate a point on the axis to set the circumference of circle D.* Alternately, it may have resembled the corresponding circle D in NMI W.6, described next (see Fig. 6.2).

Circles E. 5.3 From the centre of circle *A*, (1) copy length *b* along the 60° lines (cf. Fig. 2.2) on either side to locate a point on the circumference of circle *E*. Divide in half the length a measured from the outer circle *A* (2, 3), and copy that measure to locate centres of circles *E* along those lines (4).

Circles F. 5.4 See the drawing.

Table 3 lists the principal measures within the plan, again all expressed in terms of 1, 2, *a, b* (derived from 1, 2, $\sqrt{2}$) and their simple combinations.

The form of this disc is perhaps the most elegant among the seven surviving examples. That is to say, the game of the design played with quantities 1, 2, $\sqrt{2}$ proceeds in the simplest of steps and with an efficiency lacking in the others. The excellence of the form is matched by its outstanding execution by the metalsmith.

Table 3. Dimensions of N. M. I. W.5 disc

Circle A.	Radius:	1
	Diameter:	2
Circle B.	Centre:	$2a$ from bottom of circle *A*, i.e., radius = *a*
	Bottom:	*a* from bottom of circle *A*
Circle C.	Centre:	$2a$ from bottom of circle *A*
	Bottom:	½ from bottom of circle *A* (midpoint of lower half)
Circle D.	Centre:	$(1\text{-}2a)+½$ below centre of circle *B*
	Bottom:	$(1\text{-}2a)+b$ below centre of circle *B*
Circle E.	Centre:	intersection of radius of 1/3 of circle *A* with arc, same centre as circle *A* and radius 1-½*a*
	Radius:	½*a*, limited at measure *b* from centre of circle *A*
Circle F.	Diameter:	¼*a* (i.e., ½ of ½*a*). See the drawing.

The two discs that survive less than half complete are similar, and forms which can be reconstructed by analogous procedures from even one or two dimensions which are congruent with the surviving fragments of the discs.

NMI W.6 In this disc, one end of the vertical diameter is clearly defined by the location of the element we have been calling circle *D*. The centre and circumference of one of the original pair we have been calling circle *E* are still identifiable. Circle *C* is lost and circle *B* is distorted and partial. Just enough of circle A is intact (though distorted in the lower quadrant) to guide the reconstruction. The form, so far as it is preserved, has several of the traits of discs already described. See Fig. 6.

Circle A. 6.1 Draw the outlining circle and divide it into equal thirds and fourths.

Circle B. 6.1 It appears that $2a$ is employed twice along the vertical axis: from the bottom to locate the centre of circle B, and from the top to locate the upper limit of circle B. Because this is identical to placement of this eccentric circle in 3.1, the derivational process is not repeated here.

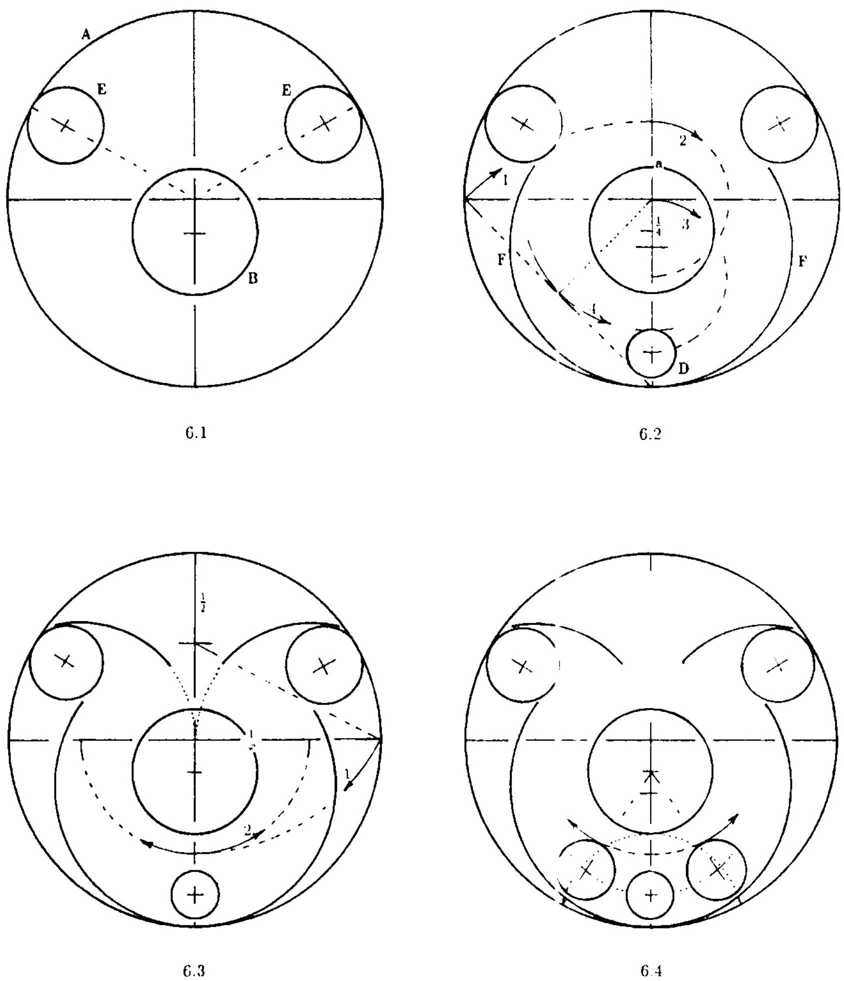

Fig. 6 A derivation of the formal plan of NMI W.6.

Circle C. Too incomplete to be analysable.

Circle D. 6.2 Its centre is $2a$ below the centre of the plan; either copy the measure $2a$ already marked from the bottom of the plan, or (1) plot measure a above the centre of the plan (cf. Fig. 2.3), copy it (2) below the centre, then (3) double that measure along the vertical axis, as shown. Its radius reaches to $\frac{1}{2}c$ below the centre of the plan (4).

Circle E. 6.1 Its centre is along the radius extending to the one-third division of the upper part of the main circle (cf. Fig. 2.4). It is located at $\frac{1}{2}a$ from the rim of the main circle, and its inner limit is measure b from the centre of the piece. Both of these settings are identical to those derived in 5.3, and for that reason the derivational process is not shown here.

Circle F. 6.2 The outer embracing arcs follow circular paths until they approach the vertical axis, both above and below. Their derivation is uncertain, but may have been something like this. Centre is located at measure ¼ below centre of the plan (its derivation not shown in this figure), radius reaching to the bottom of the plan. (The inner embracing arcs do not follow circular paths.)

'Eyebrow'. 6.3 The ridge of the 'eyebrow' is circular, having its centre on the horizontal axis at measure $1/\varphi$ from the centre (1, 2, the same relative measure as b in Fig. 10.1), and radius $1/\varphi$.

Spirals flanking circle D. 6.4 Centres lie along an arc with centre 1/2c above the bottom of the plan (can be copied from 6.2), the arc passing through centre of circle D. Their locations along this arc are plotted as in 4.4. The measure $1/\varphi$ (set in 6.3) from centre of the plan determines the radii of their areas.

NMI W.1 This is the other piece surviving in less than half its original form. The reconstruction of its form, to follow, is a bit more complex than those reconstructions of discs described thus far. None of the derivational steps is different from those used elsewhere in this paper: it is only that the mixings of measures based on 1 and 2 and $\sqrt{2}$ and $\sqrt{3}$ are more varied. Layout of the form can be replicated as follows. See Fig. 7.

Circle A. 7.1 Draw circle A, divided as usual into two, three, and four equal parts.

Circle B. 7.1 The centre is located as in Figs. 2-3 (derivation not shown again here). Its top is $\frac{1}{2}a$ above the centre of circle A: find the half-measure of the radius of circle A (as in Fig. 2.4) and mark it on the horizontal radius (1); then from the midpoint of the lower half of the vertical axis copy (2) the measure to the midpoint of the horizontal axis (length $\frac{1}{2}c$) along the vertical axis above ($\frac{1}{2}c - \frac{1}{2} = \frac{1}{2}a$).

Circle C. 7.4 Radius set by marking $\sqrt{3}$-1 of the outer circle's measure from the top of the form. The mechanics of the process are as follows. Begin by deriving $\sqrt{3}$-1 for the overall measure (diameter) of circle A. Mark the division of circle A into thirds, from the bottom of the vertical axis

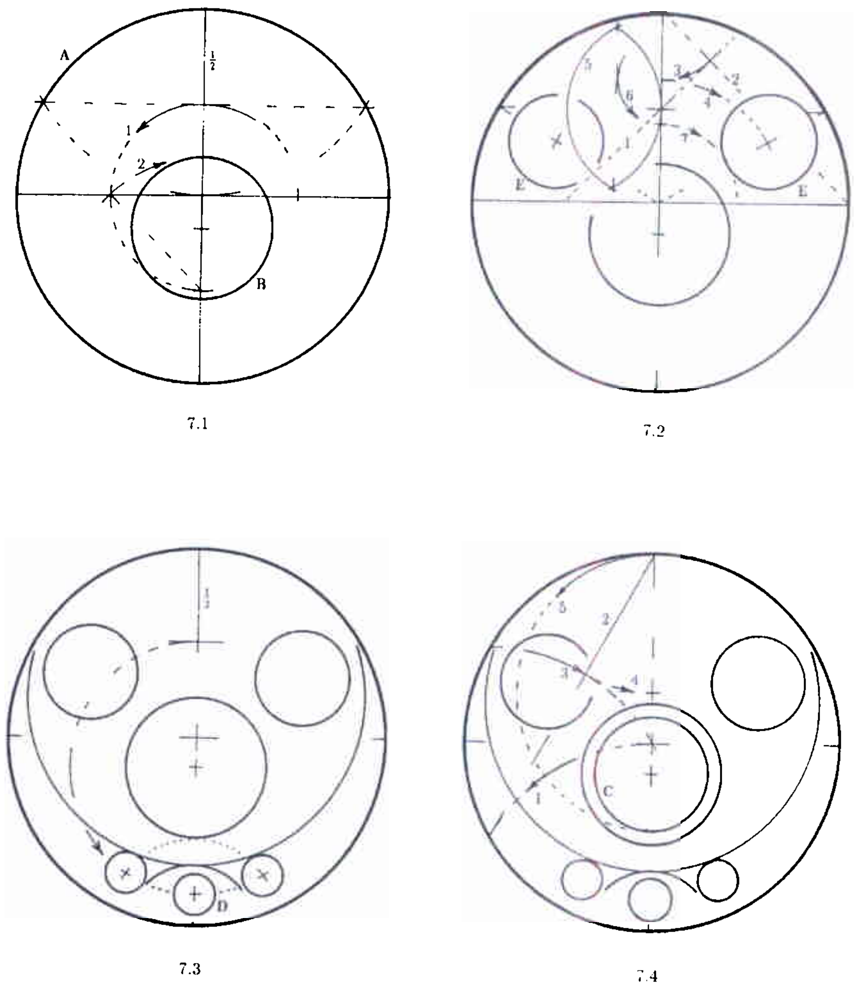

Fig. 7 A derivation of the formal plan of NMI W.1.

(1) (simply the inverse of Fig. 2.2). Sketch a line (2) from the top of the vertical axis to a point just marked, measuring $\sqrt{3}$ in length; from the lower end of that line ('8 o'clock' point) copy (3) the radial measure 1 of the main circle to mark a point on that line, which leaves $\sqrt{3}$-1 above. Transfer that measure to the vertical axis (4), then double it (5) to mark $\sqrt{3}$-1 of the diameter of circle *A* on the vertical axis. That sets the radial measure of circle *C*, concentric with circle *B*.

Circle D. 7.3 Centre is set by taking the measure from the centre of circle *B* to midpoint of the upper radius of circle *A*, and copying it below centre of circle *B*. (As executed this element is not quite circular). An arc through that centre, with its centre shared by circles *B/C*, which is traced by the copying just done, passes through the centres of the flanking spiral devices; another arc, centred at bottom of the vertical axis, radius reaching to circle B, passes through the centres of the flanking spirals.

Circle E. 7.2 Centres lie along radii of circle A to the one-third division of the top of circle A, as in all the other discs. To locate the centres, find ¼c from the outer circle (A) and copy it on each radius just noted. Radius measure is ¼. Using the half-measure of the radii already marked for plotting circle B (in 7.1), project the chord (1) of a quadrant with radius ½ to intersect the chord (2) of a quadrant of the outer circle (radius =1). From the top of the vertical axis, copy the measure to that intersection to mark a point along the vertical axis (3); then from the centre of circle A, copy the measure to that last point along the two lines (as in Fig. 2.4) to locate the centres of circles E (4). To set the radius, find the measure ¼. To plot it in place, see the drawing (5, 6, 7).

In Fig. 7.3-4 a partial circle tangent to circle D and its two flanking devices has been drawn, extending upwards to embrace the eccentric circular element and the 'eyes'. Its centre is the

Fig. 8 B.M. CIIAA No. 792. Photo © The Trustees of The British Museum.

intersection of top of circle B with the vertical axis (i.e., ½a above the centre of circle A); its radius extends to ½ below the centre of circle B. These embracing curves in the disc are not circular, curving inwards at either end. Its inclusion here is only to register a guess at how they may have been planned.

When we see that these five discs consistently have the eccentric inner circles with their centres in exactly the same place (relative to the whole-disc circle), we may be inspired to go off searching for 'the meaning' of this consistent offset and the governance of the designs by the one key ratio that sets those centres. There is something broadly similar in an astronomical diagram a millenium and a half later, in Johannes Kepler's representation of the eccentric orbit of Mars, in *Astronomia Nova*, trashing once for all the notion of perfect circles for the orbits of planetary motion. Before investing a lot of time in such a search for meaning, however, we should consider the remaining two discs, B.M. CIIAA No. 792 and NMI W.2.

B.M. CIIAA No. 792 While the design of the British Museum disc (Fig. 8) has elements not present in the previous ones, it follows the same principles, utilises the same methods, and shares the basic terms that set its dimensions. It has one principal difference, in that this design develops the basic terms with further use of 2 as a divisor. Fig. 9 shows a different way of dividing the basic measures 1, 2, a, b, c successively by two, yielding halves, fourths, etc. of each of them. This method will be employed in reconstructing the form of the B.M disc.

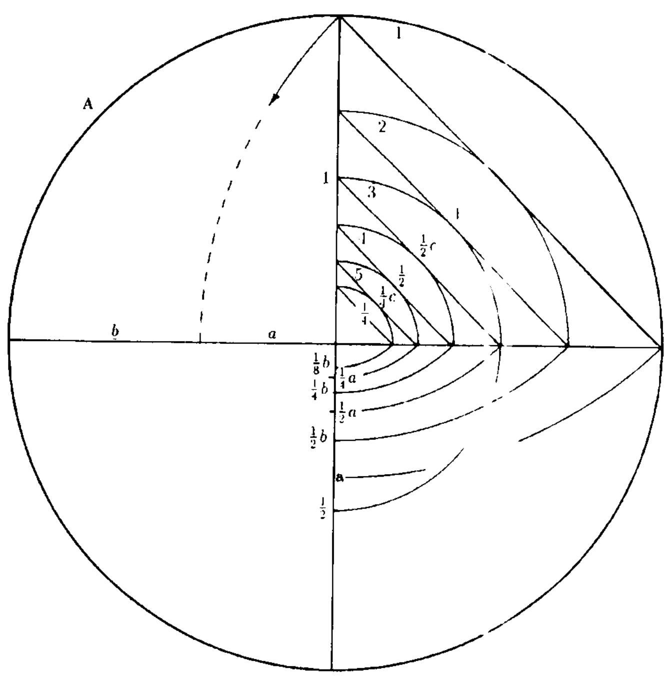

Fig. 9 A way to generate a chain of half-measures of 1, 2, a, b, c from 1+1 at straight angle, and 1+1 at right angle.

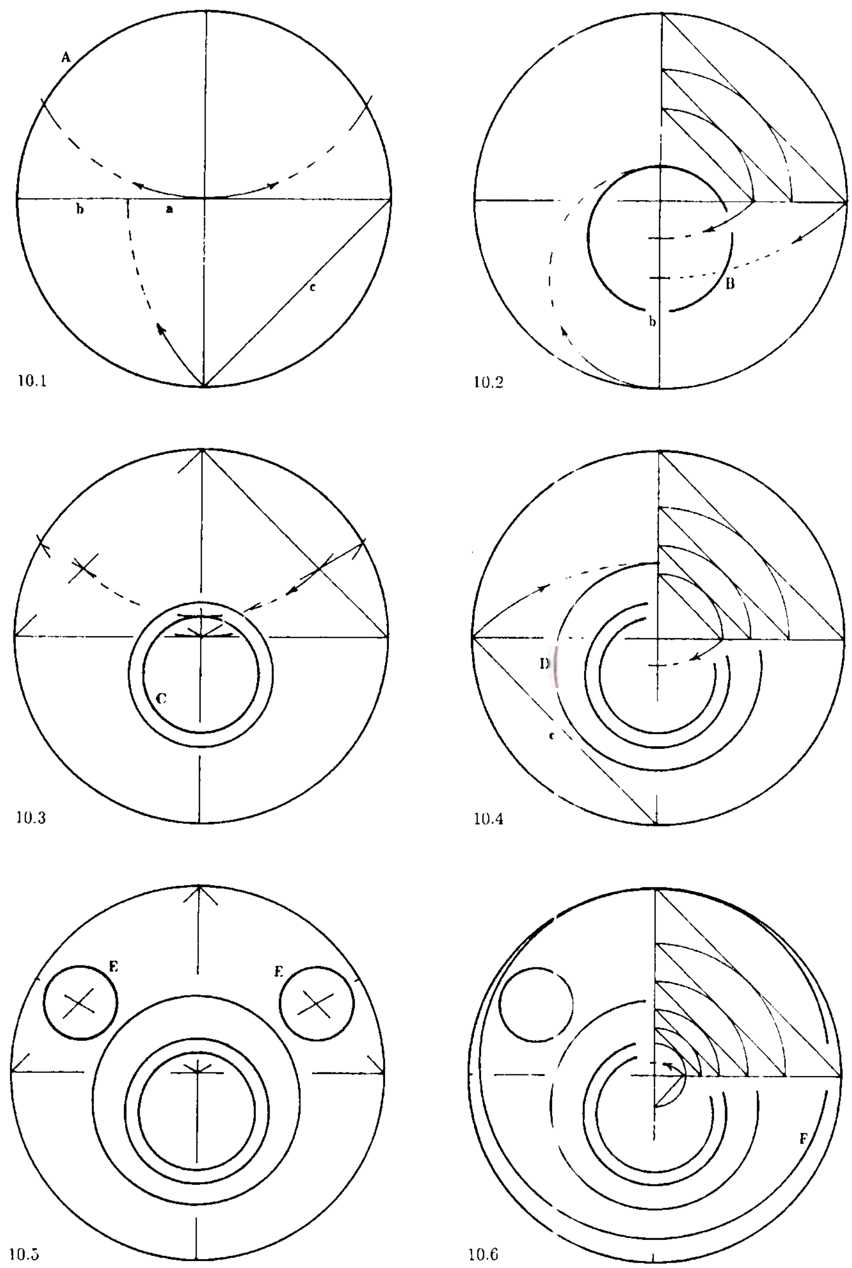

Fig. 10 A derivation of the formal plan of BM CIIAA No. 792
(using measures generated as in Fig. 9).

Directions for constructing the principal elements of the plan are given next. In setting each circle within this plan, too, all that is required is location of its centre and the measure of its radius—from its centre to any point on its circumference. All except circles *E* have their centres along the vertical diameter of circle *A*, so that only their vertical measures along this axis need to be set. See Fig. 10.

Circle A. 10.1 Draw circle *A*, divided as usual into two, three, and four equal parts. Sketch the chord *c* of a quadrant, and copy that measure along a diameter, dividing a radius into two segments *b* and *a*.

Circle B. 10.2 Along the centreline copy the length of the chord of the third circle from its upper end to locate the centre for circles *B* and *C*. Also along the centreline double the measure *b* from the bottom of the form to set the radius of circle *B*. (This is equivalent to doubling measure *a* from the top of the plan, as in Figs. 3.1 and 4.1.)

Circle C. 10.3 Sketch radii to the marks in the upper area defining one-third the cirumference of the overall circle (as in Figs. 2.2 and 10.1). Then mark intersections of those radii with chords of the upper quadrants of circle *A*. From the top of the vertical axis, copy the measure to either of these intersections along that axis, setting the radius of circle *C*. (Cf. 4.2.)

Table 4. Dimensions of B. M. CIIAA No. 792

Circle A.	Radius:	1
	Diameter:	2
Circle B.	Centre:	$1+\frac{1}{2}a$ from top of circle *A*
		$\frac{1}{2}+\frac{1}{2}b$ from bottom of circle *A*
	Top:	$2a$ from top of circle *A*
		$2b$ from bottom of circle *A*
Circle C.	Centre:	Same as circle *B*
	Top:	$1-\frac{1}{4}a$ from top of circle *A*
		[same as top of circle *A* to centre of circle *E*]
Circle D.	Top:	b from top of circle *A*
		a above centre of circle *A*
		c above bottom of circle *A*
	Centre:	$\frac{1}{4}b$ below centre of circle *A*
Circle E.	Centre:	Intersection of chord of upper quadrant of circle *A* with a radius to the point dividing circle *A* into thirds.
	Radius:	$\frac{1}{2}a$ (diameter: a)
Circle F.	Top:	same as top of circle *A*
	Bottom:	$\frac{1}{4}b$ above bottom of circle *A*
	Centre:	$\frac{1}{8}b$ above centre of circle *A*

Circle D. 10.4 Along the centreline copy the length of the chord of the fourth circle from its upper end to locate the centre for circle *D*. From the bottom of the form copy measure *c* on the vertical axis to set the radius for this circle.

Circle E. 10.5 Centres are at the intersections of chords and radii set in plotting circle *C*. Copy the measure ½*a* for the radius (readily found as the measure from the centre of circle a to the centre of circles *B/C*, set in 10.2).

Circle F. 10.6 Along the centreline copy the length of the radius of the sixth circle below the midline of the form, to mark a point on the centreline; then copy the chord of a quadrant of the sixth circle to mark a point (⅛*b*) above the midline of the form. Radius for this is the measure from the centre to the top of the form (circle *A*).

Listed in Table 4 are dimensions for the circular elements within the design, again expressed as functions of 1, 2, *a, b, c*. Various formulations are provided, to represent various clues to constructions that will produce the forms. Extensive iteration of both measure and ratio will be apparent in the listing and in the directions for construction.

NMI W.2 Finally, this disc is a real botch. The paired coils ('eyes') are so unlike each other that only location of their centres can be employed in understanding the form. The inner eccentric circular area is quite unround. The arcs on either side of it are unmatched and unround both. The rim is irregularly wrought. Still, the signature ratio cannot be mistaken. It is there is the location of the key inner circular area, together with the other formal features. This disc uses not $\sqrt{2}$, but another basic 'geometrical ratio' of measure, φ, or 'golden ratio', as it later came to be called ($2{:}\sqrt{5} - 1$). In brief outline, here is a derivation of the primary parts of the form. See Fig. 11.

Circle A. 11.1 As before, with division into halves, thirds, and fourths. Then, because the key ratio for this one disc is different, two methods of setting it are illustrated first: in either case, the immediate purpose is to locate the centre of the eccentric inner circular area.

11.1 From the midpoint of the upper vertical radius to an end of a horizontal radius is a measure to be copied (1) and marked on the lower segment of the vertical axis. The radius of circle *A* (=1) is now divided into two measures *b* and *a*. Doubling measure *a* (2) will locate the centre for circles *B* and *C* which outline the eccentric circular area.

11.2 Sketch a line (1) from the top of the form to the midpoint of a horizontal radius, mark half the measure of the radius along that line (2), and copy the remaining measure along the vertical axis (3). The radius of circle *A* is again divided into two measures *a* and *b*. Doubling measure *b* (4) will locate the centre for circles *B* and *C*.

Circle B. 11.3 Centre was located in 11.1 or 11.2. As in 10.3, sketch radii of circle *A* to the marks in the upper area defining one-third the circumference of the overall circle (as in Figs. 2.4 and 10.1). Then mark intersections of those radii with chords of the upper quadrants of circle *A*. From the top of the vertical axis, copy the measure to either of these intersections along that axis, setting the radius of circle *B*. (Cf. 4.2.)

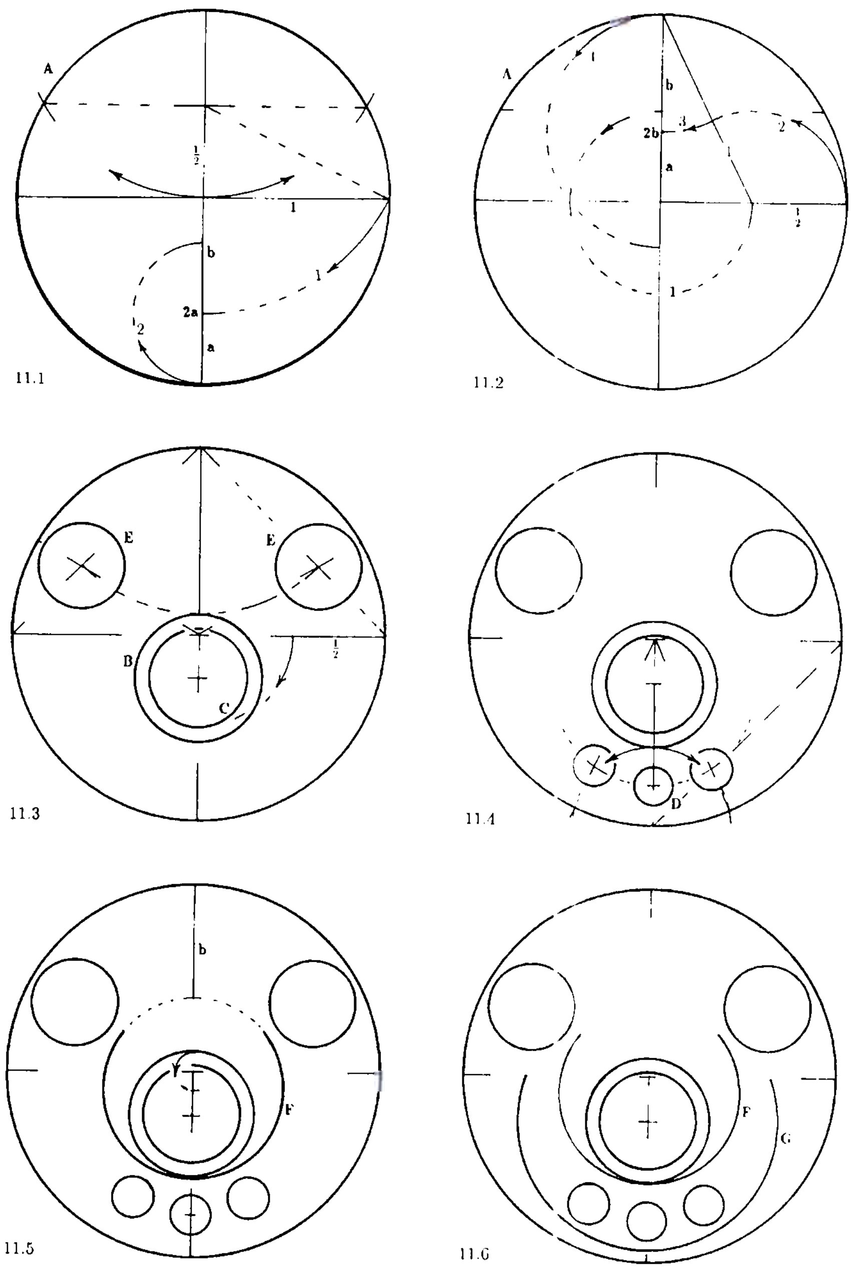

Fig. 11 A derivation of the formal plan of NMI W.2.

Circle C. 11.3 Centre same as for circle *B*. As in Fig. 5.1, radius is set by marking the midpoint of the lower vertical axis.

Circle D. 11.4 From the centre of circles *B/C*, copy the measure to a tangent of a chord of a lower quadrant to mark a point on the lower vertical axis (cf. Fig. 3.3). Radius is uncertain.

Circle E. 11.3 Centres already set, same as in 4.4 and 10.5. Radius is probably a copy of the measure between the centre of circle *A* and circles *B/C*. The uneven execution of the paired coils within these areas, however, makes the planned radial measure uncertain.

Arcs F. 11.5 Centre is set by copying the measure between top of circle *A* and top of circle *B*, to mark a point on the vertical axis below the centre of the design. Radius reaches to measure *b* below top of the design.

Arcs G. 11.6 Centre is same as that of circles *B/C*. Radius to $\frac{1}{2}(1 - a)$ below that point (derivational method uncertain).

ACCURACY OF THE DISCS' DIMENSIONS

The topic of accuracy of the discs' dimensions needs a brief introductory note. The models *should* match the forms of the discs. After all, they are based on the discs' forms, and have been tested repeatedly to assure a match which seemed to be as thorough and precise as can be attained. It is in aberrations from this match that departures from accuracy can then be posited. Most of the discussion of the individual pieces will concern the centres and outlines of circles. The circular elements are either accurately rendered or they are not. Sometimes, as in W.5 and the B.M. disc, they follow precisely at a constant measure from a fixed point-that is, they are accurate circles. In others the circles are 'flattened' or 'spread' or otherwise distorted. This much can be established without reference to a model. On the other hand, when compared to the models proposed here, the centres of all these circles (perfect or not) turn out to be 'accurate', for being unfailingly at the ostensible centres of the circular elements. In general, all these pieces appear to be surprisingly accurate for copying by repoussé into sheet bronze the geometric essentials of schemes like those illustrated, which I believe to underlie their forms. When copied with the skill evident in every aspect of W.5, circles and their centres are exactly as in the model—'accurate' in every respect. When copied less skilfully (or even with ham-fisted execution as in W.2), it is the roundness of circles that is inaccurately rendered even while their sizes and centres can be said to have been accurately set.

NMI W.3 (Fig. 3) A photograph of this disc reveals the inaccuracies in its construction just about as well as does direct and careful examination of the artefact itself.[8] Circles *A, D, E* are accurate both in their circumferences and in the locations of their centres. Their outlines are well defined. Circles *B* and *C* have their common centre located exactly as in the model, but their outlines are noticeably unround: in the orientation employed here ('eyes' above middle, symmetry on either side of vertical axis), they appear to be spread to either side; alternatively they are squeezed (so to speak) at top and bottom. The model represented in Fig. 3 uses the dimensions on the vertical axis as its basis.[9]

In the execution of this part of the plan, the rise on the inside from the basic surface of the disc—to form what is represented as circle *C*—is fairly uniform all round. The rise on the outside—from the disc's 'floor' to what is represented as circle *B*—shows considerable variation, being a sharp rise where it is tangent to the buffers by the 'eyes' and also at the bottom where it is tangent to the paired arcs that link the 'eyes'; laterally, though, the rise is gradual or more rounded. Thus the rounded section for the 'eccentrically-placed' circular area is uneven both in its main lines and in how it is worked up from the main surface of the disc.

NMI W.4 (Fig. 4) A photograph of this disc shows the inaccuracy of the eccentric rounded section unmistakably, along with asymmetries of the arcs enclosing this distinctive circular area. The distortion of this circular area is more pronounced than it is in W.3; most obvious is the severe flattening of the top of the ring (circles *B, C*). Circle *B* in the disc measures 105 mm horizontally, about 99 mm vertically. There are also run-ups to the outside of circle *B* that are like those in W.3, with the gradual rise laterally and the sharper rise at top and bottom.

Otherwise, the disc and the proposed original plan match very well. In the orientation adopted here, the outer circle *A* is accurately rendered, when allowance is made for a flange on the rim resulting from the metal having been bent outwards, from its turn-under that is used for all the discs to define and rigidify the outer circle. Centres and circumferences of circles *D* and *E* in the metal match their positions and sizes in the model.

For the most noticeable deviation from accurate circles, in *B* and *C*, I have no plausible explanation. It would be easy to attribute it to the dominance of the 'eyebrow' and 'nose-bridge' arcs—if only we had a way to explain that dominance in the development of the whole form. What that way might entail is not at all clear. Or to dismiss the matter as expecting more logic and discipline than the design of these discs required would be erroneous, if the precision, discipline, and details of the best-wrought pieces is taken into account. The shared centres of these two circles is just where the plan shows, and the vertical measure of circle *B* (*c*. 99 mm) is the same as the one predicted by the model.

NMI W.5 (Fig. 5) The accuracy and skill of workmanship embodied in this disc is no less than astonishing.

Attention belongs first to the distinctive eccentric circular area, this time—in contrast to the two examples preceding—for its flawless accuracy both in execution and in siting. This area, represented as outlined by circles *B, C* in the plan, comprises a deep bowl, approximately 40 mm from its upper rim to its lower (underside) surface. Its outside measure, where the walls yield unequivocal dimensions, is a constant 111 mm. Circle *B*, that is, is a very, very accurately-wrought circular construction.

Next, if the plan in Fig. 5 is right, the measure between the top of the disc (circle *A*) and the top of the eccentric rounded area (circle *B*) can be closely calculated. The geometric computation is represented in the diagram. The arithmetic computation goes as follows.

Circle B diameter is 111 mm, radius 55.5 mm.
Circle B radius is a (= $\sqrt{2}$ - 1) in relation to circle A radius (= 1),
or, circle B is approximately 0.4142 of circle A
(alternatively, circle A is $\sqrt{2}$ + 1 (= 2.4142) that of circle B);
By arithmetic, circle A should have radius *c*. 134 mm

Next, the top of circle B is $3a$ from the lower limit of circle A,
or in arithmetical approximation, $2 - 3a = 0.7574$;
By arithmetic, the measure from top of circle B to top of circle A should be
$0.7574 \times 134 = 100.5$ mm.

That is exactly (to well under half a millimeter) the measure in the metal disc.

All this exercise in arithmetic may at first encounter seem purposeless, or perhaps inviting specious inference, given the damage to the disc's outline. The lower part of the rim defining the enclosing circle (A) is gone. On the right-hand side (in the orientation being employed), beside the 'eye' the rim structure is bent outward, and again the rim structure at about the 4 o'clock position is bent outward. On the left-hand side a smaller aberrant outward bend is found again beside the 'eye' segment. On the other hand, the upper one-third of the rim is intact (the 10-2 o'clock segment). Along the rim of this one-third of the disc the structure is simple and consistent, as the sheet is smoothly curved upwards, to the sharp bend to form a lip—a turn-down or turn-back sufficient to make a rigid and rounded edge for the disc. In short, with the perfect condition of this segment of the perimeter one can infer an equal precision originally in other parts of the plan and an extraordinary accuracy in its execution.

The lower two-thirds of the rim is differently structured wherever any parts of its remain. It is formed as a sharp and straight-up bend in the bronze sheet, with the lip formed by a tight turn-down of the metal. It is very likely that this difference in structures of the main segments of the rim (outlining circle A) is reflected in the survival of one segment intact and the loss of the other segment from its being more fragile. The transition from the sloping approach to the rim above the 'eyes' to the abrupt bend-up below them is clearly observable, and it is one of several parts of this piece that is deserving of the highest admiration for the smith's arts.

For the small circles F within the spirals which arise from the 'eyes' of the plan, the derivational account of the form of this disc (above) reads simply 'See the drawing'. The drawing, Fig. 5.4, epitomises both the efficiency and the elegance of the geometrical coherence of the form of disc W.5. One has only to replicate the construction illustrated in Fig. 5.1, 3, 4 to get (literally) a feel for the handling of proportion: the size and location of these two circles follows simply and purely from the proportions of the whole plan. That much reflects the fine handling of the geometric scheme of the design in even this small element. The superlative craft of the smith in executing the scheme in metal is perhaps at its most impressive in these circles at the centres of the 'eyes'. They lie within the usual spirals that evolve within circles with centres along radii offset exactly 60° from the vertical axis. These spirals in W.5 are 'beautifully sharp-edged, regularly drawn "keeled" curves'[10] (one convex surface, the other concave) which also have a cleanly made, narrow 'spine' along the vertex. The enclosed circles are wrought similarly, and it is the narrow 'spine' on each that is represented in Fig. 5 as circles F.

Further, the spiral structures rise from the main surface of the disc very markedly (*c.* 10 mm) and recede, rise again and recede to where they transmute into the 'eyebrow' arcs. The round bud-like areas within them also rise markedly, though only about half as high; being circular rather than spiral, the rise and fall produces a plain slant for the upper 'spines' that form circles *F*. In the geometrical scheme proposed here, these spines are circles *F* enclosed off-centre within larger round areas, which lie within spirals, which are enclosed by circles *E*; and these spines are executed on a slant of perhaps 20°.

Remarkable indeed, then, is the accuracy of registration that can be seen when a careful drawing of the plan described above is superimposed on a photograph of the disc. The match of model and photo is nowhere sharper or more exact than in the situation and size of circles *E* and *F*.

The upper element at least of the 'eyebrow' arcs seems to conform to the same geometrical scheme. In Fig. 5.4 their paths are traced from about where they join the spirals from circles *E* as they proceed inwards. Their centres lie along the same lines used to plot centres for circles *F*, at their inner intersections with circles *E*.

NMI W.6 (Fig. 6) Reconstruction of the form, and assessment of the accuracy of its original execution, are both handicapped by the damage and distortion of the remnant. The surviving portion is now bent from its (presumed) original circular symmetry. The outer ring (circle *A* in the plan) was made in a manner similar to the other, this time with a short, sharp, perpendicular bend upwards from the face of the disc, a turn-down of the edge, and a bit of tuck-under.

That much is intact in the 8-10 o'clock range of the outer rim. Above that range—as the rim passes the 'eye'—it is bent outwards. Below that range there is separation from the main surface of the disc. Essentially, only about one-sixth of the outer circle can be used in studying the form and the smith's accuracy.

The remnants of circles *E* and *D* are sufficient for such study (interdependent with determining the dimension of circle *A*).

Analysis of the hallmark element, the eccentric circular area, is least certain. The expected inner circle *C*, as noted earlier, is entirely gone. The outer circle *B*—what is left of it—is distorted, with some bits of metal bent inwards, some bits bent outwards. Enough remains, though, to trace its original path and to locate its centre.

Insofar as the piece can be studied for its basic form, the model and the artefact match quite closely.

NMI W.1 (Fig. 7) In the surviving half of this disc there are no distortions, and the formal aspects of the overall form are clearly delineated. It is only slightly dished.

The rim is carefully wrought, turning down smoothly to form a band perpendicular to the main surface, then turning under to reach half-way back to the disc's underside, all the while describing the path of an accurate circle.

The surface section enclosing the eccentric inner circle is rounded, as usual, but where it rises from the main surface the turn is sharp and distinct, clearly marking the paths of circles *B* and *C*. Similarly, the turn-up from the face of the disc to outline the one surviving 'eye' is abrupt, well-defined, and regular. And similarly, the triad of devices at the lower portion of the plan have clearly executed outlines (as well as spirals and arcs within them).

The skill in producing the spirals and other curvilinear elements within the 'eye' is evident in a photograph, and far more impressive when the three dimensions of their construction can be seen directly from various angles. They are executed in deep relief, the upper portions of their surfaces following the plane curved patterns while at the same time rising and falling markedly from the main surface.

Altogether, when the design in bronze is compared to a carefully drawn geometric model like the one represented in Fig. 7, the accuracy in rendering the design is as fine as the technical skills in metalworking that produced this disc.

B.M. CIAA No. 792 (Fig. 10) I have not examined this disc. The fundamental circles *A, B, C, E* in the model and in a photograph of this disc have complete and accurate registration. (There is no element corresponding to circle *D* in the other discs, or corresponding to the spiral devices on either side of it.) The arc *F* in the drawing follows the inner working of the raised arc very closely (cf. similar arcs in W.2), while arc *D* follows the model in its lower portion, but diverges as it approaches the 'eyes'.

NMI W.2 (Fig. 11) In contrast to W.1, this piece is deeply dished. Furthermore, the dishing is unusual in having its lowest main surface at about the top of the off-centre rounded area.

The rim of this piece is different from the others, both for not keeping to an accurate circle, and for the way in which it was formed. Instead of sharp bends to and from the outer surface (perpendicular to the face), this one is formed by rolling the sheet to form a partial spiral as it turns from the face and proceeds to the tuck-under within that. Further, the formation of the rim differs in different places along the circle. Along the opposed 8-9 o'clock and 2-3 o'clock segments the face curves gradually upward to the downturn for the rim. Along the symmetrical 10-11 o'clock and 1-2 o'clock segments there is a distinct upturn of the face before the downturn for the outer edge. Some other parts are virtually flat until the downturn occurs.

Circle *D* and the flanking devices are distinctly formed, and circle *D* itself is more accurate than it appears in a photograph: its being executed on a slant gives it the appearance of an ellipse in the plane image of a photograph.

The outlines of circles *B* and *C* are quite unround, and not even symmetrical in their distortions. In cross-section, they arise and descend from the main surface in smooth curves (rather than sharp bends); the curves are consistent around both perimeters, so that the distortion of circles *B* and *C* cannot be attributed to misunderstanding their material structures. Nonetheless, they are disposed symmetrically on either side of the vertical axis. The fit of the geometric model to a photograph is good along the vertical axis, and generally in the 11-1 o'clock areas; it is not good elsewhere, where the metalworking is quite unround.

The paired coils within circles E are so differently—and so poorly—wrought that only their centres can be relied upon for understanding the plan for this disc. On the left, the work-up to form the spiral has the same structure as that for circles *B* and *C*. On the right, along the outside (nearest the rim), the coil has a sharp bend-up, even to an acute angle, to form a flat outer surface.

In the drawing (Fig. 11) are two circular arcs having centres below the centre of the disc; they correspond closely to the inner outlines of the raised devices of the disc.

SUMMARY

'Tradition and the individual talent' (to borrow from literary criticism) expresses the relationships among these designs in bronze metalworking, whatever the purpose of discs of this type may have been.[11] They do not represent a fixed form, like that of the sonnet, so much as a traditional method of devising forms of a traditional type.

I think we have enough before us now to imagine a designer at work.[12] Never mind his appearance, his surroundings—the weather, the smells, the noises—or his language. We need only watch him work. His tools are dividers and straight-edge. Those we can see. What we cannot see, or hear, or read are the rules and rationale of the artistic game which he is playing, and the conventions of playing it. They would have been learned by apprenticeship. At our remove, apprenticeship is achieved by patient reconstruction of the manoeuvres with those tools that will replicate one, then another, then another of the forms that have survived—and by absorption of the aesthetic imperative that governed the tradition in which they were created.

Along the way, we can learn a number of things about designing these seven discs. Chief among them is that only with complete coherence of its proportions will a form satisfy the designer: the geometry of these plans must generate a perfect harmony among all its parts.

We can further infer a number of things about how this first principle is met again and again, without need for repetition of form. In every case, the design is circumscribed (so to speak) with a circle. The enclosed area is developed with bilateral symmetry, and there is no other symmetry, inverse or otherwise. A plain circular area is located off-centre slightly 'below' the middle of the plan. A symmetrical pair of spiral devices often called 'eyes' are placed 'above' the middle, located exactly along lines radiating from the centre at 60° to either side of the vertical centreline. Beyond the basics may be enclosing arcs, 'eyebrows', and small cells of ornament symmetrically disposed near the bottom of the form.

Upon this cantus firmus the form of each piece is then composed. In every instance it is in the disposition of its elements that coherence of proportion inheres, and this depends upon specific conceptions of quantitative relations, carefully managed. Six of the surviving designs share a common set of proportions involving combinations of 1, 2, $\sqrt{2}$; or in plainest terms, the measure of 1 and 1 joined in a straight angle, and of 1 and 1 joined in a right angle. The seventh develops proportions involving combinations of 1, 2, φ; in plainest terms, the measure 1 and 1 at a straight angle and 1 at a right angle to one end of that. What they all have in common is not a ratio (obviously), or a formula; rather, it is a principle of dividing the overall dimension, the diameter measure, into two equal parts (the radial measures, conspicuous in the bilateral symmetry), and then dividing one of those two equal parts into two unequal parts, whose measures have been called a and b. When the division is carried out in the ways illustrated, if $\sqrt{2}$ is the key to the geometrical ratios, the separate measures interlock as $a:b = 1:(1+a)$, or $1:a = (2+a):1$, for example. If φ is the key $(2:(\sqrt{5}-1))$, the measures interlock as $a:b = b:1$ or $a:b = 1:(1+b)$, for example. In one instance a third division yields $\sqrt{3}$, which also divides radial measure into two unequal segments. Only proportions built from these simply devised key measures are used in creating the designs.

With this severe restriction, it is not surprising that a number of conventions of designing should become evident. Locating the centre of the eccentric circular area is achieved in six instances by doubling the shorter segment *a* from the bottom, or by doubling the longer segment *b* from the top; and note that this convention is employed whether the key ratio is based on $\sqrt{2}$ or on φ. Use of the midpoint of a vertical radius to set the radius on an inner circle is used twice. Location of centres for the paired coils, within what have been called circles *E*, is achieved three times as the intersection of chords of quadrants and the radii at 60° from vertical. And so on.

In every respect, the rules and the conventions of laying out the forms of Monasterevin discs are consistent with those that are employed much later in the best examples of Insular art, especially the sculptured high crosses and the cross and other decorative pages in the illuminated Gospels manuscripts.[13] The shared principles—those common strings of DNA, as it were—have not been recognised in the mainline studies of later Insular art any more than they have been recognised in this earlier metalwork. Even in the recent review of diagnostic features of Insular art by George and Isabel Henderson, in *The Art of the Picts*, this element in Insular art remains unnoticed. They say: Insular style is 'essentially abstract and decorative, consisting of a set series of linear rhythmic motifs and patterns, many of them originating in the visual traditions of separate ethnic groups'—spirals, scrolls, strap- and cord-work, ... 'various zigzag motifs, formed into regular step, key and fret patterns.' It is, they say, the 'combination of a number of previously unconnected motifs' that is the hallmark of the style.[14]

One cannot quarrel with any element of this characterisation of Insular style, except for one crucial omission: while the decorative contents have been studied exhaustively, their containers generally have been ignored. In much of the best work in the Insular tradition, the 'combination of previously unconnected motifs' takes place within plans of the kind just illustrated: their plans embody rigorous and thorough apportionment of areas according to a coherent and exclusive scheme. This typically coherent geometry of carpet pages, high crosses, decorative metalwork is as much a feature of Insular art as is any of the decorative motifs or patterns or or any of their various combinations. Rules and conventions of creating the overall forms have an unbroken history in earlier Irish art and in still earlier Celtic art. One unmistakable segment of that history is preserved in the discs of Monasterevin provenance and style.

POSTSCRIPT

Many of the forms also can be constructed from an initial configuration that does not employ the second diameter at right angles to the first, shown in all the figures above starting with Fig. 2.1, step 3. Fig. 12 shows a model for a different beginning for the designing process of discs like these. For some disc forms it seems to be fully sufficient, the measures 1, 2, *a*, *b*, *c* based on $\sqrt{2}$ emerging from this alternative model, and in locations needed to develop the forms. So does $\sqrt{3}$ which, though not listed in the descriptions of the forms as they have been derived, is present nonetheless in measures from the centre of a disc to the centres of circles *E* in Figs. 4.4, 10.5, and 11.3. The constructions shown in Figs. 2-10 are easier to derive precise measures from and have greater transparency in displaying proportional relations; also, the complexity of the plan in Figs. 9-10 would be difficult to develop from this alternative source. Even so, it is an open question at this point whether it may be preferable to trace some of the discs' forms from this other potential beginning. Either way, the designs embody the same full and traceable cohesion among their proportional measures.

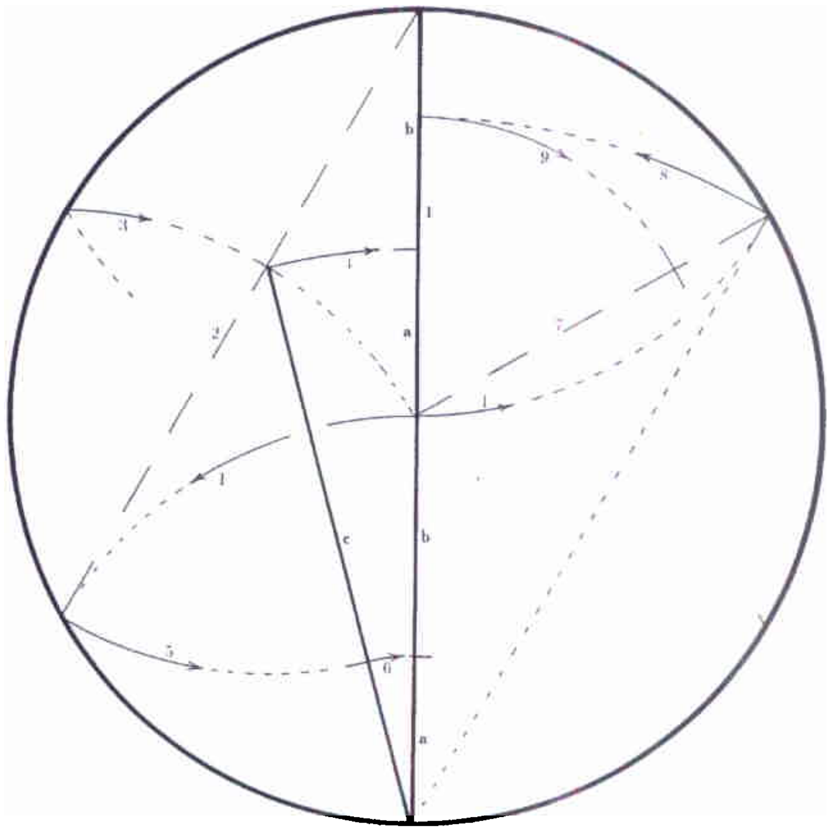

Fig. 12 Alternate initial steps in deriving forms of Monasterevin-type discs.

Here is the procedure for construction, in brief. Begin with the enclosing circle and a (vertical) diameter. From either end of the diameter mark the length of the circle's radius (= 1) along the circumference (1, 1). Shown on the left: sketch a line (2) between two of the six segments of the circle, then subtract the radius measure from it (3), and then (4) copy the measure shown (c) to mark a point on the diameter, dividing a radius into segments b and a. The results are the same as produced in Fig. 2.3. Or, subtract the radius measure from c (5) and copy the remaining segment of c to the vertical diameter (6), dividing it into segments a and b. The results are the same as produced in Fig. 2.4.

Sketching lines (7) to the one-sixth divisions of the circles on either side of the diameter locates one of the coordinates of circles E in all seven discs—same result as produced in Fig. 2.2. Two more steps (8-9) locate the centres of circles E in three discs, as listed above.

NOTES

1. W. R. Wilde, *A Descriptive Catalogue of the Antiquities of Animal Materials and Bronze in the Museum of the Royal Irish Academy* (Dublin, 1861), 639.
2. Barry Raftery, *La Tène in Ireland: Problems of Origin and Chronology* (Marburg, 1984), 276.
3. J. V. S. Megaw, *Art of the European Iron Age: A Study of the Elusive Image* (New York, 1970), 158. Or earlier, the description by Stuart Piggott and Glyn E. Daniel, *A Picture Book of Ancient British Art* (Cambridge, 1951), 20, reads: 'While the ornament is essentially a geometrical fanatasy it is difficult not to see a grotesque face behind the fantasy—the eyes represented by the scrolls and the open mouth by the sunken circle'. See also John Waddell, *The Prehistoric Archaeology of Ireland* (Galway, 1998), 316.
4. Wilde (note 1), 637. See also photo 48 in Piggott and Daniel (note 3).
5. This disc is also described as a final example in my paper 'The Ancestry of "Coherent Geometry" in Insular Art', *JRSAI*, 134 (2004): 5-32.
6. The circles (E) enclose the areas within which the spirals form; the spirals have not expanded to the limits of the circles where the circles are tangent to the diameter.
7. Raftery (note 2), 278-79.
8. With permission of Eamonn P. Kelly, Keeper, and with gracious assistance by Margaret Lannin, I was able to examine carefully the six discs in the National Museum of Ireland in June 2005.
9. The lowest limit of circle *B* now falls about where it would be if this circle had its radius set at one-half the radius of circle A (even as the radius of circle *C* was set for NMI W.5). This seems less likely to be the intended dimension than the one in the plotting that has been proposed, because it entails several anomalies that otherwise would not appear.
10. Raftery (note 2), 279.
11. With seven known examples, their function is still unknown. According to Eamonn P. Kelly, 'The Iron Age', in *Treasures of the National Museum of Ireland: Irish Antiquities*, ed. Patrick F. Wallace and Raghnall Ó Floinn (Dublin, 2002), 133, 'They may have had a ceremonial or parade function, perhaps suspended from the sides of chariots'.
12. The discs 'are sufficiently close to one another in details of ornament and design to suggest that they come from a single workshop' according to Barry Raftery, 'La Tène in Ireland', in M. Ryan, ed., *Ireland and Insular Art, AD 500-1200* (Dublin, 1987), 17. The prominent differences among the discs, on the other hand, may point to tradition more directly than they do to a single workshop.
13. Robert D. Stevick, *The Earliest Irish and English Bookarts: Visual and Poetic Forms before A. D. 1000* (Philadelphia, 1994); '*Shapes of Early Sculptured Crosses of Ireland*', *Gesta*, XXXVIII (1999), 3-21; 'The Shape of the Durrow Cross', *Peritia*, 13 (1999), 142-53; 'The Coherent Geometry of Two Irish High Crosses', *Peritia*, 14 (2000), 297-322; 'The Form of the Tara Brooch', *JRSAI*, 128 (1998), 5-16; 'The Form of the Hunterston Brooch', *Medieval Archaeology*, XLVII (2003), 21-39.
14. George and Isabel Henderson, *The Art of the Picts* (New York, 2004), 15