

What the Bronzes from Hunyuan Tell Us about the Foundry at Houma

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In 1923 a rainstorm at Hunyuan in northern Shanxi province exposed a hoard of ancient bronzes which quickly found their way into museum collections both in China and abroad. In 1957 the foundry where the Hunyuan bronzes are likely to have been cast was discovered 500 kilometres south of Hunyuan, during archaeological surveys at Houma in southern Shanxi. Excavations at the Houma foundry site between 1957 and 1965 unearthed several thousand pieces of clay casting debris – mould fragments and related items – bearing lavish decoration that serves to connect bronzes from Hunyuan and many other places with Houma (Fig. 1). In the sixth and fifth centuries BC Houma was the capital of the powerful state of Jin, and the Hunyuan bronzes are almost certainly fifth century Jin products. Most of the bronzes mentioned in the present article are from Hunyuan: the 1923 find included several small quadrupeds (see Fig. 2, in the Freer Gallery of Art, Washington, DC, one of at least three identical animals, perhaps matched supports for a vessel), a large buffalo in the Shanghai Museum (see Fig. 3), and a pair of *hu* vessels, also in the Shanghai Museum (see Fig. 8). The

Freer Gallery's *hu* shown in Figure 11 is not from Hunyuan, but comparison with the foundry debris leaves little doubt that it too was cast at Houma (compare for instance Figs 1 and 12).

The Houma foundry debris tells us *where* these bronzes were cast, but it does not tell us *how* they were cast. Where processes are concerned, the debris is better at revealing details than fundamentals. The foundry's operations were organized around a radically new mould-making procedure, a procedure that depended on objects like the one shown in Figure 1, yet looking at that fragment we could never guess how it was used. The Houma excavators were unable to produce a workable reconstruction of the procedure; as Barbara Keyser demon-



(Fig. 1) Clay foundry debris (pattern block fragment, mirror-reversed for comparison with Fig. 12)

From the foundry site at Houma, Shanxi province

First half of 5th century BC

Clay

Height 12 cm, width 10 cm (approximate); height of dragon interlace band 5.7 cm

Courtesy of the Institute of Archaeology, Shanxi province

strated in a paper published fifteen years ago, the key to the procedure is not in the foundry debris but in the bronzes themselves.

The mould-making procedure Keyser reconstructed is immensely complex, and it will be easier to understand if we approach it indirectly. Consider first the small quadruped in the Freer Gallery (Fig. 2). Though cast at Houma, it was cast not by the foundry's most sophisticated technique but by a much simpler process that had been in use for almost a thousand years by the time the Houma foundry began operations. The process started with a clay model of the animal. On this model the craftsman carved all the decoration we now see on the bronze. To form a mould the craftsman applied fine wet clay to the model and then removed this clay envelope in sections. The sections, keyed to fit together, were reassembled around a clay core (a core which to this day remains inside the bronze). Molten metal was poured in, and the sections were broken off to reveal the finished animal.

This process has two advantages. First, the model is reusable. Several moulds could be formed on it, and from them identical

bronzes could be cast. Though for reasons unknown (and this is a major unsolved problem), this advantage was not exploited in earlier times, it was exploited by Houma casters: the proof is the other two quadrupeds identical to the one in Figure 2 (in the British Museum in London and the Asian Art Museum of San Francisco).

The second advantage is that decorating the model allows the decorator to fit his patterns to the object he is decorating. This advantage is immediately obvious if we compare the Freer quadruped with the animal shown in Figure 3, a cross between a buffalo and a steamship. One of these animals wears a tailored suit, the other wears a patchwork quilt. Both objects were made



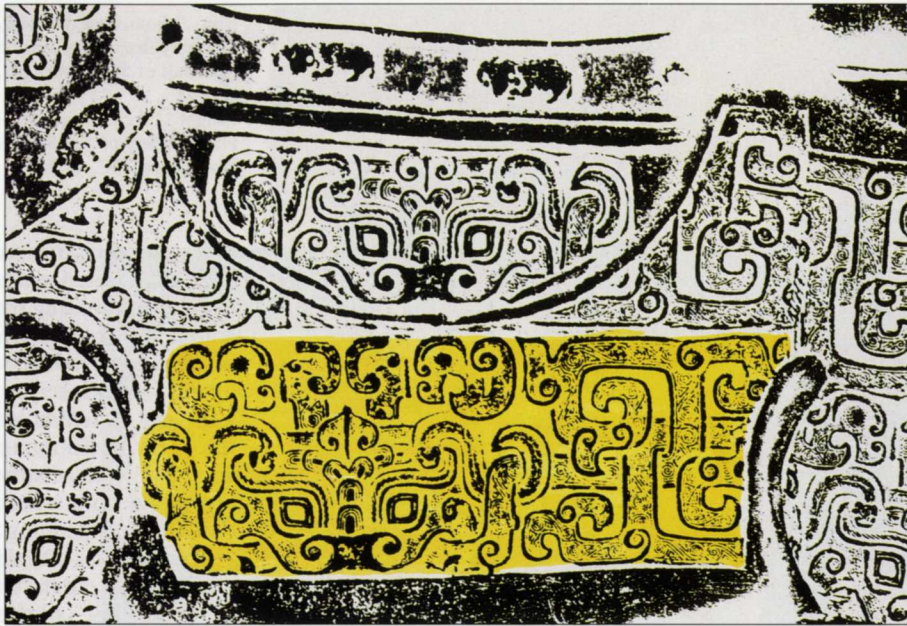
(Fig. 2) Four-legged animal
Probably from Hunyuan county, Shanxi province
First half of 5th century BC
Bronze
Height 11.8 cm, length 20.4 cm
Freer Gallery of Art, Smithsonian Institution,
Washington, DC, 48.24

at Houma, but the buffalo was *not* made from a decorated model. The Houma foundry is an engrossing puzzle because, though Houma casters knew perfectly well how to use decorated models, they rarely did, preferring instead a very different procedure with very different advantages and liabilities. The buffalo, an unusually clumsy Houma product, displays chiefly the liabilities: this decorative disaster offers a quick route to understanding the procedure.

Examine first the decoration on the belly of the buffalo. In the rubbing shown in Figure 4 the unit coloured yellow, about 18



(Fig. 3) Buffalo-shaped vessel
From Hunyuan county, Shanxi province
First half of 5th century BC
Bronze
Height 33.7 cm, length 58.7 cm
Shanghai Museum
(After Higuchi Takayasu and Enjōji Jirō, *Chūgoku seidōki hyakūsen*, Tokyo, 1984, pl. 69)



(Fig. 4) Rubbing from the buffalo in Figure 3
Length of unit coloured yellow c. 18 cm

centimetres long, contains a staring *taotie* face at the left end and some interlaced ribbons, intricately curved and branched, at the right end. Above the *taotie* the heads of two dragons with bulbous noses face away from each other, their necks sprouting from the *taotie*'s head. One of the interlaced ribbons to the right of the *taotie* can be interpreted as the body of one of the dragons, so in this whimsical design the dragon's body, caught in the snake-like crest of the *taotie*, runs down into the *taotie*'s mouth

and out through the top of its head.

Now notice that, apart from the patterns on the buffalo's horns and a few small recumbent animals on its neck and central smokestack, *all of the buffalo's decoration is identical to some part of the unit coloured yellow in the rubbing* (Fig. 5). Twenty-three exact copies of the unit were somehow made, trimmed, and bent to provide the patchy decoration we see on the finished buffalo (several patches are upside down!). Figure 6 is a detail



(Fig. 5) Rubbing from the buffalo in Figure 3



(Fig. 6) Belly and foreleg of the buffalo in Figure 3
Author's photograph, reproduced courtesy of the Shanghai Museum

(Fig. 7) Head of the buffalo in Figure 3
(After Ma Chengyuan and Chen Peifen, *Bronzi dell'antica Cina*, Milan, 1988, p. 142)

of belly and foreleg that allows us to compare two of the patches more closely. Trimming the unit to fit the foreleg deprived the dragons of their snouts and the *taotie* of its crests; also lost were the interlaced dragon bodies that should appear to the right of the *taotie* (compare Fig. 4). Yet if we have any doubts that the two *taotie* in Figure 6 are mechanically-made duplicates of each other, we may eradicate our doubts by making two identical photographic negatives from Figure 6 and superimposing one *taotie* on the other. The units are identical.

The buffalo thus draws our attention to three bewildering features of the Houma foundry's technique. First, units of decoration could be mechanically replicated: the unit coloured yellow in Figure 4 appears, in whole or in part, twenty-three times on the buffalo. Second, the units could be trimmed to suit the spaces to be decorated (Figs 5-7). Third, the units could be bent: this is clear on the hind-quarters of the buffalo, even more obvious on its snout (Fig. 7).

What mould-making procedure could conceivably account for these observations? Barbara Keyser's careful study of other Houma bronzes suggests an answer. It seems that we must imagine the following sequence of steps. First, an undecorated model of the buffalo was made. Second, a clay mould was formed on the model; in other words, clay was packed around the model and then removed from it in sections. The sections constituted the outer part of the mould (a core corresponding to the hollow interior of the buffalo was also required). Since the model was undecorated, the sections removed from it were also undecorated.

The next step was to decorate the inner walls of the mould sections. For this purpose the mould-maker employed a *reusable baked clay pattern block* – a block on which the pattern unit coloured yellow in Figure 4 had been carved. Soft clay was applied to the block and then peeled off, carrying with it an impression of the decoration. The negative peeled from the block was trimmed, bent, and laid into the mould. This operation was repeated twenty-three times, producing a mould the interior of which was plastered with twenty-three variously trimmed negatives taken from a single carved block. Though handling the negatives, planting them in the mould, and baking



the mould without damaging it must have been formidable tasks, they were managed somehow: there is no escaping the fact that identical patterns on the buffalo are differently curved and differently cropped. Houma bronzes tell us clearly that any reconstruction of the Houma technique must at some stage involve the bending and trimming of replicated units.

A word should be added to explain why the foregoing reconstruction has assumed that the units were applied to the mould rather than to the model. In theory the replicated units could have been positives rather than negatives. In other words,

instead of generating negatives and planting them in the mould, the craftsman could have generated positives and applied them to the model. The strongest indication that this was not his procedure comes from matched pairs of bronzes, such as the pair of *hu* now in the Shanghai Museum (Fig. 8 and its mate). If the craftsman had generated positives and used them to decorate a model for these *hu*, duplicate moulds could have been formed on that model, and duplicate *hu* could have been cast. The two *hu* would then be identical in the sense that the quadruped of Figure 2 and its mates are identical. Comparison shows, however, that they are not; the two vessels were made with the same set of pattern blocks, but the decorating process was carried out *twice*, independently. Presumably, then, since there is no obvious reason for making two independent models, two moulds were being decorated. The caster must have begun with an undecorated model, formed two undecorated moulds on it, and then decorated the mould sections. This order of operations had at least the advantage that removing mould sections from an undecorated model was effortless.

The Shanghai buffalo serves admirably as a primer of pattern-block mould-making, but it does not tell us why the Houma foundry routinely preferred pattern blocks (Fig. 3) to decorated models (Fig. 2). Decorated models had sufficed for

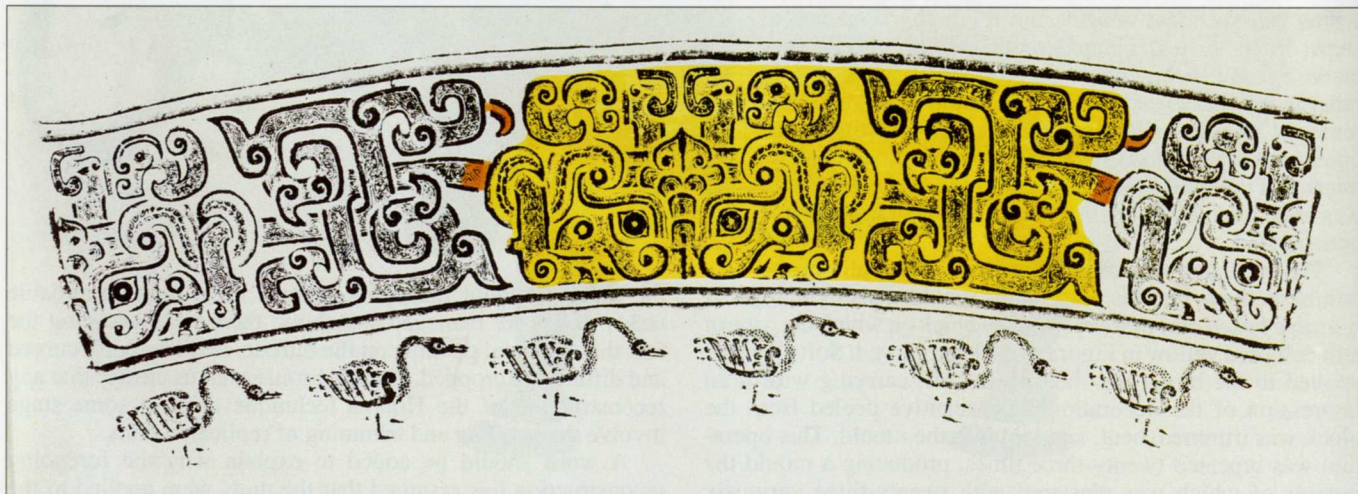


(Fig. 8) One of a pair of *hu*
From Hunyuan county, Shanxi province
First half of 5th century BC
Bronze
Height 44.2 cm, greatest circumference 80.7 cm
Courtesy of the Shanghai Museum

for *hu* vessels (see Fig. 11). The pair of *hu* in Shanghai have lost their handles (only stumps remain to show where they were), but on the Freer *hu* the handles survive, and the handles are important because the design of the main register is coordinated with them: two *taotie* are oriented to the front and back, two are on axis with the handles. On these *hu* vessels, therefore,

centuries to produce bronzes at least as sophisticated as anything the Houma foundry ever attempted; why would the foundry exchange a straightforward and proven technique for the hazards of a process that required assembling moulds from dozens of fragile clay negatives? An object as atypical as the buffalo is unlikely to supply an answer, and we must turn now to the foundry's normal products. The pattern block which produced the yellow unit in Figure 4 can hardly have been designed for decorating buffaloes; what was it meant to do? The rubbing in Figure 9 suggests an answer: it shows us that the unit will join on itself to produce a continuous horizontal pattern in which successive *taotie* faces are separated by the tangled bodies of the dragons they swallow.

The rubbing in Figure 9 comes from the main register of the Shanghai *hu* – it corresponds to exactly half the circumference – and if we look for a moment at a similarly decorated *hu* in the Freer Gallery we may be able to convince ourselves that this pattern was designed specifically



(Fig. 9) Rubbing of main register of the Shanghai *hu* in Figure 8
Length of unit coloured yellow 19.5 cm

the circumference of the main register must be four times the length of the pattern unit (the Shanghai *hu* rubbing in Figure 9 ends, left and right, on the axes of the lost handles). The designer of the Shanghai pair unfortunately miscalculated the circumference – the moulds were a trifle too large – and the mould-maker had to insert fudge factors. The mould-maker laid the four negatives in place, with the *taotie* faces properly oriented to the front, back, and sides; then, because the negatives did not quite fill the circumference, he joined them together, by carving directly in the mould. The point where he joined two of the units is at the centre of Figure 10: the person who carved the pattern block carved curvilinear spirals, but the person who touched up the mould carved angular spirals. Two of the four retouchings in this register are included in Figure 9, where they are coloured orange: the retouchings can be identified as such – they cannot have been on the pattern block – because they differ from each other. They show us the mould-maker touching up the mould before casting, and the mould-maker's objective, clearly, was to maintain a simple but vital relationship between the pattern and the vessel's shape.

It seems safe to conclude that the pattern block used to decorate the Shanghai buffalo was meant for *hu* vessels; perhaps some obstinate Jin lord insisted on having a buffalo decorated to match a *hu* he owned. Discovering the proper use of this one block is only a first step towards explaining why the Houma foundry used pattern blocks, however, for most registers on *hu* vessels were not made in the same way as the main register; they were made more efficiently.

On the Freer *hu* notice that only the main register and the pendant triangles below it are coordinated with the handles: only they had to be planned (Fig. 11). We might unsuspectingly assume that each of the other registers was similarly produced by a pattern block dedicated to it, a pattern block sized and curved so that four or five or six negatives taken from it would exactly fill the register, but we would be wrong. The Shanghai buffalo has already alerted us that pattern blocks are not limited to fixed curvatures or shapes, and the Houma foundry made shrewd use of this advantage. The maker of the Freer *hu* knew that the staring *taotie* faces in the main register would catch our

attention, and he knew that if a face was cut short, or not exactly centred between the handles, we would complain at once of a glaring error. He therefore made the circumference of the main register four times the length of the pattern block and ensured that no error would occur. He knew also, however, that the other registers, lacking bilateral symmetry, were more intricate and less dominating, and that particularly if our attention was drawn elsewhere, we would take their continuity for granted; and wherever he was sure that we would take continuity for granted, he let discontinuities occur. His foundry's efficiency depended on his grasp of applied psychology.

To understand why discontinuities occur we must examine one of those other registers. Consider for instance the register of interlaced dragons just above the main register on the Freer *hu*. The dragons in this register all face right but alternate right-side-up and upside-down (Fig. 12). The pattern block which produced them contained four dragons (close examination of this register shows that the four-dragon block was not carved but made by replication from a block that contained two dragons, meaning that here we are actually seeing the product of two stages of replication). The four-dragon block carried also the braid below the dragons, but not the braid above them.

Now let us visualize how this block was used. The mould for the Freer *hu* was in two sections, like the halves of an avocado with the pit removed, and the mould-maker's job was to transfer decoration from the pattern block to the mould. He took a clay negative off the block and laid it into one of the mould sections, bending it and trimming its edges as necessary; he took a second negative and laid it next to the first; and so on. When he reached the edge of the mould section, some portion of the negative extended beyond the edge, so he sliced that portion off and laid it at the adjacent edge of the other mould section. (We know this because the mould marks, which are aligned with the handles, cut through the decoration in all registers.) In this manner he worked his way around the circumference of the mould. When he returned to his starting point, however, he found a gap: occasionally he was lucky, but as a rule the circumference of the register would not turn out to be an integer multiple of the pattern-block length. He therefore

took one last negative from the block and cut a slice from it to fill the gap. Figure 13 is a detail of the same register as Figure 12, but the portion shown in Figure 13 includes the filled gap, 2 centimetres wide: this is the place where the laying of negatives in this register began and ended. (The boundaries of the abbreviated unit are clearly visible in the lower braid band [arrows].) Every register on the Freer *hu* contains similar abbreviated units except the main register (by design), the pendant triangles below the main register (also by design), and the register of interlace at the neck of the vessel (luck, with a little fudging). The abbreviations are ran-



(Fig. 10) Detail of main register of the Shanghai *hu* in Figure 8
Length and width of angular spiral section carved in mould approximately .75 cm
Author's photograph, reproduced courtesy of the Shanghai Museum



(Fig. 11) *Hu*
 First half of 5th century BC
 Bronze
 Height 44.8 cm, greatest
 circumference 83.5 cm
 Courtesy of the Freer Gallery of
 Art, Smithsonian Institution,
 Washington, DC, 57.22



(Fig. 12) Detail of Freer *hu* in
 Figure 11, dragon interlace just
 above main register
 Height of dragon interlace 4.9 cm
 Author's photograph, reproduced
 courtesy of the Freer Gallery of Art

domly distributed over the vessel; in other words, the various bands were laid from different starting points, presumably because discontinuities would be more likely to attract notice if they were all aligned. In practice the irregularities are not easy to find even for an observer who knows to look for them; measuring off pattern repeats is the only sure way.

Inconspicuous breaks in apparently continuous patterns are not occasional mishaps, nor are they a trivial technical detail; they are the Houma foundry's signature, a constant feature of the bronzes it produced. If it is disturbing to be told that Houma bronzes are sprinkled with imperfections, return from Figure 13 – a photograph taken to show an imperfection – to Figure 11; better yet, visit the Freer Gallery. The Jin lord for whom the Freer *hu* was made was not disturbed by imperfections, because he was too dazzled to notice them; only nearsighted pedants notice them. It must be emphasized that we cannot explain the vessels on which we find irregularities as the foundry's second-class products, made with blocks originally designed for first-class products; if this were true, we should sooner or later be able to find one of those first-class bronzes, free of irregularities, finer than the Freer *hu*. The reader is welcome to hunt for it.

The Freer *hu* in fact demonstrates both that the Houma foundry was able to make bronzes to any required technical standard and that it was prepared to take shortcuts whenever an opportunity presented itself. Let us imagine a scale of premeditation in the use of pattern blocks, with the Shanghai buffalo at one extreme (no planning) and the main registers of *hu* vessels at the other (exact planning). Most registers of the Freer *hu* fall between the two extremes, and study of other Houma bronzes suggests that in this respect they are typical of the foundry's output as a whole. In the few cases where design considerations made abbreviations unacceptable, they were avoided, but the rest of the time the foundry assumed that a modicum of discretion would be enough to ensure that abbreviations would not be noticed or, if noticed, would not offend. Since labour costs in antiquity are unlikely to have been the dire consideration that they are today, a concern for efficiency at Houma is an unexpected finding, but the systematic taking of shortcuts we see on

Houma bronzes seems inescapably to imply that the foundry was concerned with productivity or efficiency.

How much efficiency could be extracted from pattern blocks depended on how many shortcuts could be taken, and this in turn depended on prevailing taste in bronze design. If fifth century fashion had required any large fraction of the foundry's output to be planned as carefully as the main registers of *hu* vessels, pattern blocks might have enjoyed only a modest competitive advantage over decorated models. Long before the fifth century, however, patrons had ceased to expect bold motifs tightly coordinated with vessel shapes, and a fashion that was content with richly textured surfaces gave enormous advantage to a technique in which trimming and bending of negatives allowed decoration from one pattern block to be applied to the contours of a variety of moulds. The Musée Guimet in Paris owns several bronzes from the Hunyuan hoard which differ in shape but which bear decoration taken from a single pattern block. The carver of that block did not need to have a particular vessel shape in mind, and his job may well have been quite separate from that of the vessel designer (who might be imagined as a sort of project coordinator). Even if a pattern unit was originally carved with a particular shape in mind, it could be applied to others as well. The carver who executed a design for a *hu* might find to his dismay that the mould-making crew had pasted his work onto a buffalo.

In our admiration for a technique which multiplies the carver's work so efficiently, we should not forget that the carver's labour was saved at the expense of the mould-maker. The carver no longer had to spend time carving entire decorated models, but the mould-maker now had the delicate chore of assembling a mould from clay negatives, and if a duplicate vessel was required, he had to go through the whole process again. The adoption of pattern blocks amounted to a coordinated restructuring of the foundry's activities at two distinct points in the process of manufacture, and at the second of those points, the mould-making stage, the new procedure entailed unprecedented technical difficulties. Skilled carvers may have been costly or in short supply, and the pattern-block technique certainly made the best imaginable use of their labour, but



(Fig. 13) Detail of Freer *hu* in Figure 11, same band as Figure 12, portion where laying of band started and ended
Author's photograph, reproduced courtesy of the Freer Gallery of Art

whatever premium their skills commanded, so drastic a reorganization of the foundry's work cannot have been undertaken simply because carvers were highly valued. We must instead suppose that the foundry was hard pressed to meet demand for its products. Fashion made shortcuts possible, but only demand can have made them standard procedure. Perhaps it was not the carvers alone whose labour was being used efficiently. The work of assembling moulds may also have been newly organized, in ways we cannot reconstruct, for newly efficient handling by a team. Modern assembly-line production has taught us that subdividing processes offers many advantages – a lower unit cost and a higher rate of production, along with quicker training of more narrowly specialized workers. The use of pattern blocks might be only one aspect of a larger readjustment that subdivided the whole process of manufacture more minutely than in the days of decorated models.

Houma bronzes vary enormously in quality, suggesting that the foundry supplied a diverse clientele. Perhaps the Jin court needed to produce cheap goods for a broad market in order to subsidize the luxuries it required for itself. The same strategy may have been adopted elsewhere too, for bronzes from other states show that the pattern-block technique was not confined to Houma. We cannot reconstruct the calculations that led the Houma foundry to organize production the way it did: there are too many unknowns. Yet it is clear that the foundry's organization – the pattern-block technique as expressed on the workshop floor – was responding to external economic pressures of some kind, and it is equally clear that the usefulness of this particular technique depended on the designs it was required to produce. Technique, design, and factory organization interact at Houma; they cannot be understood apart from each other, and indeed fuller understanding will require us to trace the interaction as it evolved over time.

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The author wishes to express his gratitude to the staffs of the Freer Gallery of Art, the Shanghai Museum, the Musée Guimet, the British Museum, and the

Asian Art Museum of San Francisco, whose kind hospitality made this study possible.

Note: Two important technical differences between the Freer and Shanghai *hu*, though they do not affect the argument of the present article, should be mentioned. First, in all registers of the Shanghai *hu*, the laying of negatives began and ended at the edges of mould sections, with the result that all irregularities lie next to mould joins; in my experience of Houma castings, this is very unusual. Second, while the main register of the Shanghai *hu* was generated from a pattern block which carried both the *taotie* and the dragon bodies to its right, the corresponding register on the Freer *hu* was generated from two pattern blocks used in alternation, one carrying the dragon bodies and the other carrying the *taotie*.

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- Umehara Sueji, *Sengoku-shiki dōki no kenkyū (Étude des bronzes des Royaumes Combattants)*, Tōhō Bunka Gakuin Kyōto Kenkyusho, Kyoto, 1936. Plates 1-28 illustrate objects from the 1923 find at Hunyuan. The Musée Guimet *ding* and *fang ding* illustrated in Umehara's plates 1 and 2 show the same pattern blocks reused on different shapes.