Fig. IA. Detail of Fig. IB, Fang yi.

Shang Ritual Bronzes: Casting Technique and Vessel Design

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The past three decades have seen a considerable change in our understanding of Shang ritual bronzes. Although it owes much to recent archaeological discoveries, this change was brought about mainly by work done outside the field of archaeology, in the study of fabrication methods. The starting point was a study of Shang mold fragments carried out by Orvar Karlbeck, who was able to show conclusively that Shang founders did not rely on the lost-wax process.[1] Karlbeck's paper was published in 1935, but his work attracted little notice at the time; it was only in the 1960s that an obvious correspondence between the appearance of Shang bronzes and the technique used to make them was finally recognized. This belated discovery has required the history of the bronzes to be rewritten from a point of view which takes casting technique into account. The art historian can no longer ignore technique or relegate it to an appendix, for neither the character of individual objects nor the history of Shang design as a whole can be understood without reference to fabrication methods.

But if the art historian no longer enjoys the luxury of discussing design without mentioning technology, neither can the historian of metal technology afford to ignore design: to do so would be to assume that Shang casters never made technical decisions on artistic grounds. Shang bronzes confront us inescapably with the problem of understanding how technique and design interacted, and a first step toward solving this problem is perhaps to recognize that we are formulating it in terms that no Shang caster would have understood. The distinction we make between technique and design is a construct inherited from our own intellectual tradition; the Shang caster learned the two things together. The firm line we draw between art history and the history of technology has more to do with the structure of our universities than with the making of Shang bronzes. The present article will not attempt to do without the words "technique" and "design," but the examples discussed should make it clear that if we continue to analyze Shang bronzes in terms so artificial, we must proceed with great care. No formulation as simple as "technique influences design" will do justice to the experience of casters who did not think in these terms.

Fig. 1B. Fang yi, ca. 12th century B.C. H. 29.8 cm. Winthrop Collection, Harvard University Art Museums (1943.52.109).

The object shown in Figure 1, a vessel of the type fang yi, can serve to introduce the main features of late Shang bronzes. It was cast about 1100 B.C., perhaps at Anyang, site of the last Shang capital. The principal motif of its decoration is an animal

Fig. 2. Detail of a fang yi, ca. 12th century B.C. Dimensions of area shown, 4.5 by 7 cm. Metropolitan Museum of Art, New York, Gift of Arthur M. Sackler (1974.268.2).

face with staring eyes, the taotie, which occupies the main register on the vessel proper and reappears upside down on the lid. Narrower registers contain creatures seen in profile. These animal motifs draw the viewer's attention irresistibly. Set off by a ground pattern of dense, finely carved spirals, they do not interact with each other but are held fast in a symmetrical array of clearly defined compartments. The compartments are bounded by heavy vertical flanges and plain horizontal strips, the plain strips coinciding with gaps in the flanges.

An enlarged detail of the decoration of another fang yi suggests one obvious connection between the appearance of these objects and the technique used to make them (Fig. 2). The fine sunken lines with their vertical walls and sharp edges point immediately to decoration made by casting. The draftsmanship of these energetically drawn, precisely angular lines is utterly unlike that of a craftsman using tools on cold metal, and it immediately distinguishes Shang bronzes from the products of other metalworking traditions. The effect is indeed so unfamiliar that it has persuaded a few observers unacquainted with casting technique that the bronze decoration copies some lost art form executed in another medium. But since the vessel was cast,

Fig. 3. Bronze head (Sargon of Akkad?) from Nineveh, ca. 2370 B.C. Iraq Museum, Baghdad. After Max Mallowan, *Early Mesopotamia and Iran* (London, 1965), fig. 74.

decoration and all, the sunken lines should not be expected to resemble lines cut in metal: they were not carved in metal but in the clay of a preliminary model. The caster began with a clay model of the vessel he wished to make, formed a mold on the model, and used the mold to cast a bronze replica of the model. The decoration of Shang bronzes owes much of its character to the fact that it was executed in clay rather than in metal.

But this is only the most superficial influence of the technique on the vessel's appearance, a matter of the caster's handwriting; casting technique holds the key to much more fundamental features. Technique plays a role in any art form, of course, but in the Shang design tradition it seems for a time to have played the leading role. To understand how this came about we must consider for a moment the uses to which bronze was put in ancient China.

In China metal was used throughout the Bronze Age to make weapons and ritual vessels. It was not employed for other purposes which to us, the heirs of Egyptian and Near Eastern civilization, seem more familiar and more natural. The Akkadian bronze portrait head shown in Figure 3, dating from the late third millennium B.C., is a royal monument of a kind abundantly represented in the art of the ancient Near East. Such objects are unknown in ancient China, where we find only a rather feeble interest in representational art and no interest at all in portraiture or the depiction of rulers. Shang metalworkers were not required by their patrons to depict the human figure, nor were they expected to describe other features of the everyday world, and as a result they enjoyed considerable freedom in certain directions. In particular, they seem to

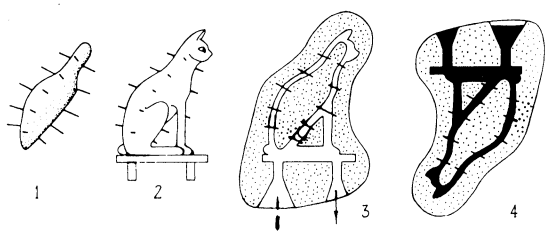

Fig. 4. Mold diagram, lost-wax process. After Henry Hodges, *Artifacts* (London, 1976), p. 72, fig. 10.

have been free to experiment with their casting method and to develop forms of decoration congenial to it. Design and technique are closely related in Shang bronzes because the designs emerged from experiments in casting technique. The early history of Shang bronzes might almost be described as an exploration of the possibilities of the section-mold technique.

But a formulation of this kind is not very meaningful in the abstract; it takes on substance only if specific illustrations can be adduced. If the designs grew out of the casting technique, how exactly did this happen? How does a casting method influence design? Can a technique direct the actions of the craftsman who uses it?

To answer these questions we must begin with the technique itself. Nowadays we believe that Shang bronzes were cast in section molds, but this is a fairly new conviction. Before 1960 most Western students of the bronzes took it for granted that Shang founders used the lost-wax process. Scholars who had no particular interest in technical matters may simply have thought of the lost-wax process as synonymous with fine casting.

The diagram in Figure 4 explains the lost-wax process in its simplest form. A founder who wishes to make a bronze cat begins by making a vaguely cat-shaped clay core (1). This core is then covered with a layer of wax, and the wax is given the exact shape desired for the finished cat: the result is a wax cat with a clay core (2). A mold is constructed by packing clay all around the cat; when the mold is baked the wax is melted out, but the core remains in place, held skewered by pins called chaplets (3). The mold is then turned upside down and bronze is poured into the space previously occupied by the wax (4). Once the metal has solidified the mold is broken open to reveal the casting—a bronze cat with a clay core.[2]

Before 1935 it seems to have been universally assumed that Chinese bronzes were cast in this way, starting from a model made of wax. As any foundryman knows, however, another procedure is available to the bronze caster, one which does not employ wax models. If the clay mold in Figure 4 had been constructed in fitted sections, so that it could be removed from the model in pieces and then reassembled around the core, there would have been no need for a model that could be melted away. The caster would have been at liberty to construct his model from clay or any other convenient material.

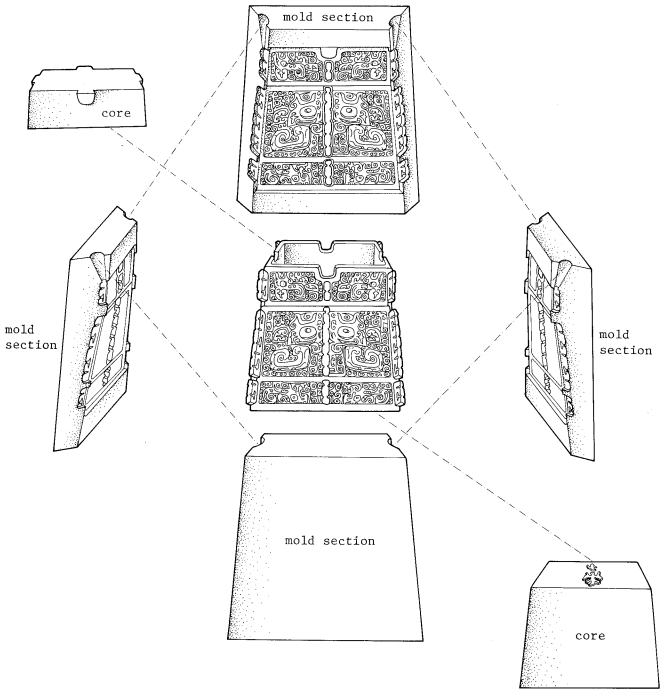

Fig. 5. Mold diagram for the fang yi of Figure 1. Drawing by Whitney Powell.

The mold diagram in Figure 5 suggests how this alternative procedure could have been used to cast the bronze vessel shown in Figure 1 (the body only: the lid was cast separately). The vessel was probably cast upside down so that the larger core could be supported from below. Since the clay model carried all the decoration that was to appear on the finished bronze, the object at the center of the diagram can represent either the model on which the mold is being formed or the finished vessel coming out of the mold; assume for the moment that it is the model. Clay was packed around this model and removed in four flat sections; afterwards the model could be discarded.[3] The mold sections were then reassembled around a suitable core, the spacing between mold and core being maintained not by chaplets but by metal spacers of the thickness desired for the casting (these would be incorporated

Fig. 6. Part of the mold for a fang yi, ca. 11th century B.C., from Anyang Yinxu Miaopu Beidi. After Guo Baojun, *Shang Zhou tongqiqun zonghe yanjiu* (Beijing, 1981), pl. 31.

in the finished vessel). Another core was inserted to form the hollow foot of the vessel, and the bronze was poured.

Parts of the mold for a similar vessel have recently been unearthed at an Anyang foundry site, and they suggest that the mold diagram in Figure 5 is not quite correct (Fig. 6). Apparently the mold for a fang yi with high-relief decoration would have been removed from the model in eight sections rather than four, and the sections would have carried mortises and tenons to ensure that they could be accurately reassembled after removal from the model. But in all essentials the moldmaking process used by Anyang casters corresponds to that illustrated in Figure 5, and it is a process which Karlbeck was able to reconstruct in his 1935 paper by studying a collection of mold fragments said to have been found at Anyang (see Fig. 11). Some of his mold fragments carried mortises and tenons, many were scorched, and a few had traces of bronze left in them. Karlbeck concluded that the fragments came from molds constructed in fitted sections and that the molds had been used to cast bronze.

At least one reader saw immediately that Karlbeck's paper had implications for the history of Shang casting. In an article published in 1937, Leroy Davidson suggested that vessels like the tripod of Figure 7 might be the earliest of decorated Chinese bronzes.[4] Davidson's argument depends on the observation that the section-mold technique allows the caster access to the interior of the mold: he can carve decoration directly in the mold surface, and lines

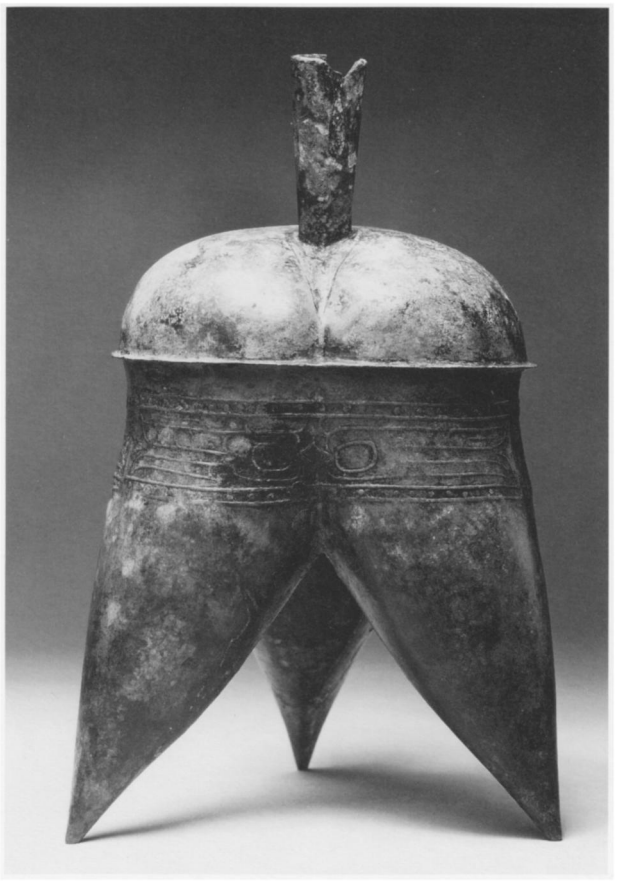

Fig. 7. He, ca. 15th century B.C. H. 22.9 cm. Brundage Collection, Asian Art Museum of San Francisco (B60B53).

cut into the mold will produce raised lines on the finished bronze. The thread-relief lines and dots seen in Figure 7 are therefore just what we might expect to find on the earliest decorated bronzes if in their first attempts at cast decoration Chinese founders chose to carve on the mold rather than on the model. It should be added that thread relief is not a form of decoration likely to arise in lost-wax casting. The lost-wax caster must carve on the wax model or the finished bronze; the mold is closed and he does not have access to its inner surfaces.

In the light of subsequent archaeological finds Davidson's reasoning seems more cogent than ever. The earliest decorated bronze vessel yet known from China, a small pitcher of the shape called jue, was discovered in 1975 at Erlitou in a level dating from about the middle of the second millennium B.C. (Fig. 9). Its decoration, which appears on the side of the vessel opposite the handle, is shown in Figure 9 in a rubbing. This simple pattern of lines and dots, which reappears in Figure 7 as the border to a more elaborate design, is more primitive than anything known at the time Davidson wrote, but it was produced, as he foresaw, by direct working of the

Fig. 8. Undecorated jue from Erlitou (3rd stratum), ca. 16th century B.C. H. 12 cm. After *Henan chutu Shang Zhou qingtongqi* (Beijing, 1981), no. 1.

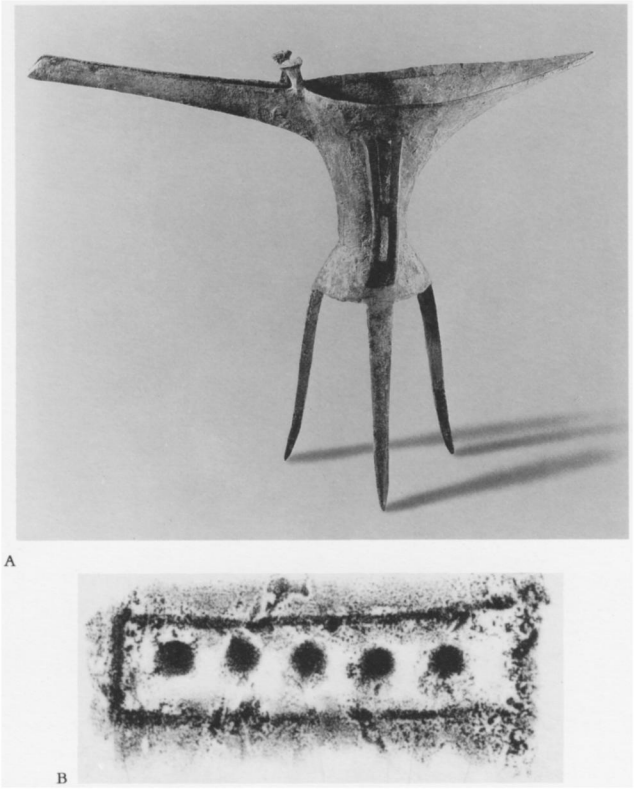

Fig. 9. A, Jue from Erlitou (3rd stratum), ca. 16th century B.C.; B, Rubbing of the side opposite the handle. H. 22.5 cm. After *Kanan-shō Hakubutsukan* (Tokyo, 1983), pl. 1; Wen Fong, ed., *The Great Bronze Age of China* (New York, 1980), fig. 17.

mold. By the middle of the second millennium B.C. the Chinese caster had discovered that he could decorate a bronze object by carving lines in mold sections. The discovery had far-reaching consequences, for it established an enduring preference for cast rather than coldworked decoration. It marks the beginning of the Shang caster's exploration of the possibilities of the section-mold technique.

At the time Davidson wrote there was no archaeological evidence to support his conjecture, and it does not seem to have attracted much notice. Karlbeck's arguments for the use of section molds, decisive though they were, did not fare much better. Well into the 1960s most writers in the West continued to speak of Chinese bronzes as lost-wax castings or else ignored technique altogether. When Western scholars did finally turn their attention to section-mold casting, they were apparently prompted not by Karlbeck's work but by the work of Chinese scholars who had long since taken Karlbeck as their point of departure.[5] Karlbeck's 1935 study had proved that Shang founders used section molds, but it had not managed to make the issue seem important.

In the course of the 1960s, however, the section-mold theory finally achieved the status of orthodoxy: after thirty years Karlbeck suddenly seemed obviously right and lost-wax seemed obviously wrong. Nowadays it is quite impossible to look at Shang bronzes and think of lost-wax casting, and to a generation of students brought up on the section-mold theory it is puzzling that scholars could ever have done so. The complete success of the new theory has made it easy to forget the obstacles which once stood in its way and the insights which overcame them.

The delayed but complete victory of the section-mold theory seems to have been brought about chiefly by two contributions. One of these was John Gettens's careful study of the joining methods used by Chinese casters.[6] Thirty years ago a vessel like the four-ram zun of Figure 10 would have been cited unhesitatingly as proof that Shang casters used the lost-wax technique: to remove a mold in sections from a model with four sets of spiralling rams' horns is unthinkable. But the conclusion that the zun is a lost-wax casting rests on the assumption that it was cast in one piece, and Gettens showed that such bronzes are not one-piece castings. In Figure 10 the horns and ears of each ram and the four small dragon heads on the vessel shoulder, altogether twenty separate pieces, were cast individually and then embedded in the mold for the remainder of the vessel. The fabrication of the zun thus involved

Fig. 10. Four-ram zun from Hunan Ningxiang, ca. 12th century B.C. H. 58.3 cm. After *Zhongguo gu qingtongqi xuan* (Beijing, 1976), no. 17.

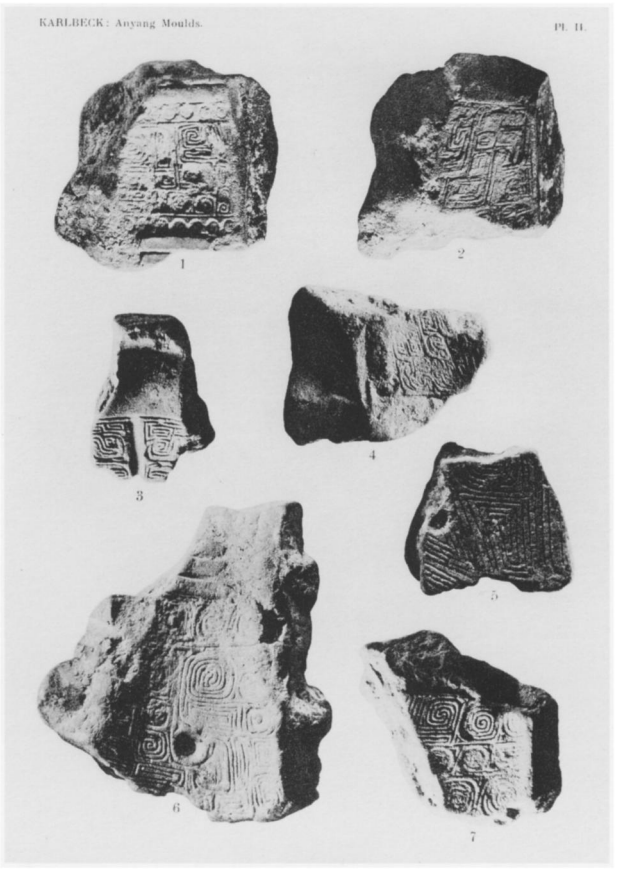

Fig. 11. Plate 2 from Orvar Karlbeck, Anyang Moulds, *Bulletin of the Museum of Far Eastern Antiquities, Stockholm* 7 (1935).

Fig. 12. Ding, ca. 14th century B.C., with detail of leg. H. 20.8 cm. Courtesy Arthur M. Sackler Gallery, Smithsonian Institution, Washington, D.C. The rounded tips of the legs are modern restorations.

twenty-one separate casting operations, the twenty precast pieces being locked in place during the casting of the twenty-first.

Gettens's paper on joining methods, which was published in 1967, removed one obstacle to the section-mold theory by explaining away the features that had seemed to require the lost-wax technique. But the observation which turned the tide against lost-wax casting had already been made in 1962 in a short paper of fundamental importance by Wilma Fairbank.[7] Mrs. Fairbank pointed out that the Shang moldmaker's technique is openly announced by his designs: the fang yi of Figure 1 almost shouts that it was cast in a mold divided vertically on the axes of its heavy flanges.

The simplest ideas can sometimes be very elusive. In Karlbeck's 1935 paper the relationship between technique and decoration does not leap to the eye because the mold fragments he illustrated were in very poor condition: in Figure 11 it is not at all obvious that the compartments of the decoration correspond to mold sections. But scholars who studied bronzes rather than molds also overlooked a relationship which seems obvious to us in Figure 1; the explanation must simply be that before Mrs. Fairbank no one who looked at the bronzes combined an interest in their design with a knowledge of how they were made. Nowadays the connection between decoration and technique seems self-evident; scholars who do not remember Karlbeck's

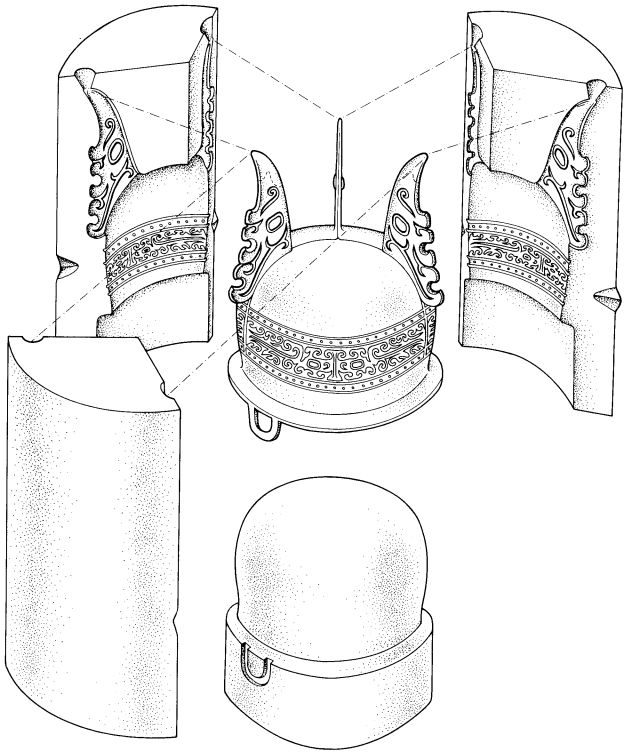

Fig. 13. Mold diagram for the ding of Figure 12. Drawing by Whitney Powell. After Bagley, *Shang Ritual Bronzes in the Arthur M. Sackler Collections* (Cambridge, Mass., 1987), fig. 100.

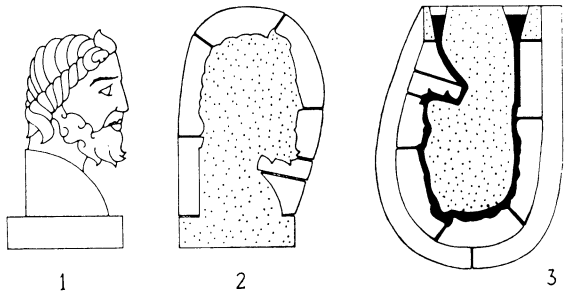

Fig. 14. Mold diagram, section-mold process. After Hodges, *Artifacts*, p. 73, fig. 11.

arguments, or who have never even read his paper, believe in section molds because they can see the consequences of the method in the bronzes. But we see the connection only because such writers as Wilma Fairbank and John Gettens drew our attention to it.

In the 1960s few pre-Anyang bronzes were known to scholars outside China, and the researches of Gettens and Fairbank necessarily centered on the highly sophisticated bronzes of the Anyang period. While Fairbank in 1962 could draw attention to a relationship between vessel design and casting technique which was instantly obvious in Anyang bronzes, she could only guess at how that relationship came about. But the excavations of the last twenty years, supplemented by increasingly full publication of material found earlier, have begun to throw light on the beginnings of the Shang bronze industry. We can now refine our understanding of the relationship between design and technique by adding a historical dimension: we can reconstruct the sequence of events which brought it into being. To do so we must look more closely at primitive castings.

The mold for a simple round vessel, such as the Erligang-phase ding of Figure 12, was normally divided into three identical sections, each of which carried the same decorative pattern (Fig. 13). The divisions between sections were aligned with the legs of the vessel so that the sections could be easily removed from the model. The decoration of the finished bronze repeats three times in the circumference of the vessel, and since the units of the decoration correspond to mold sections, the legs fall at the same points as the vertical divisions between units (Fig. 12, detail).

The relationship just described, involving the sectioning of the mold assembly, the placement of the legs, and the subdivision of the decoration, calls for two comments. First, it is a relationship specific to the ding shape; the same features are differently related in other vessel types. Second, the relationship is by no means an automatic consequence of the use of section molds. Consider the diagram used in a standard archaeological handbook to explain the section-mold technique (Fig. 14). The object being cast is a portrait head like the one shown in Figure 3. The head is shaped in clay, then the mold is formed on it and removed in sections. A considerable number of sections will be required to free the mold from the model, but the sectioning of the mold will not be expressed in the appearance of the finished head (the head will not have as many faces as the mold has sections!). If the caster's assignment is to make a king's portrait, the composite nature of the mold assembly will be automatically suppressed.

In other words, the section-mold technique does not inevitably stamp its character on the objects it produces. In the case of a portrait head we may indeed find it difficult or impossible to discover from the finished object what procedure was followed in constructing the mold. If the section-mold technique did express itself in the decoration

Fig. 15. Ding from Hubei Huangpi Panlongcheng, ca. 15th century B.C. H. 54 cm. After *Zhongguo gu qingtongqi xuan*, no. 2.

Fig. 16. Ding, ca. 12th century B.C. H. 24.8 cm. Courtesy Freer Gallery of Art, Smithsonian Institution, Washington, D.C. (60.18).

of Shang bronzes, the explanation can only be that the decoration was invented by casters whose purposes did not require them to conceal the technique. On this point the evidence of the most primitive bronzes seems fairly clear. The earliest substantial castings yet unearthed in China are ten small jue from Erlitou, objects easily cast in section molds. The Erlitou casters evidently began by making undecorated vessels (Fig. 8), for nine of the jue have no decoration, but as soon as some careless moldmaker scratched the interior of a mold section, he found that a scratch in the mold section makes a raised line on the finished bronze. The tenth Erlitou jue, which bears the simple decoration of dots and lines already discussed, must bring us very close to the time of this discovery (Fig. 9).

The fact that cast decoration was first carved directly in the mold rather than on the model might seem inconsequential, but it is to this accident that the Shang artistic tradition owes its unique character. Notice that in Figure 9 only one side of the vessel carries decoration. When the moment came to execute the decoration, the craftsman had the mold sections in front of him, but the bronze vessel did not yet exist: at that moment he must have been thinking less about the finished vessel than about the mold sections, and he was content to decorate only one of them, the largest one.

In the case of a later and more sophisticated casting, a ding from an Erligang-phase site, the entire circumference of the vessel was decorated, but the decorator continued to think in terms of self-contained mold sections (Fig. 15). The lines are raised, showing that the patterns were carved directly in the mold sections; the same pattern was carved on each section, so the decoration repeats; and, as in Figure 12, the vertical divisions in the decoration are aligned with the legs, establishing a simple but important relationship between the decoration and the shape of the vessel.

This alliance between shape and decoration is characteristic of Shang bronze design, and it is almost guaranteed by the Shang moldmaker's technique. The technique invited Shang founders to produce repetitive, compartmented designs. The designs which resulted were intimately related to the shapes on which they appeared because their layout reflected the sectioning of the mold, and the sectioning of the mold had been decided already by the shape of the vessel which was to be cast. Later generations of casters elaborated the bronze decoration far beyond anything imagined by Erligang-phase craftsmen, but the alliance with vessel shape remained intact throughout the Shang period. On the ding of Figure 16, a vessel dating from the Anyang period, the legs again coincide with the

boundaries between units of decoration, and in this case the boundaries are marked emphatically with flanges. Additional flanges give the same heavy note of emphasis to the central axis of each unit.

Introduced just before the Anyang period (see Fig. 21), flanges offered the caster a dramatic way to announce the organization of his designs and thereby to stress the relationship between decoration and shape. The prevailing interpretation of the flange does not, however, concede that flanges were adopted for the sake of this emphasis. It holds instead that the flange is the Shang caster's way of dealing with mold marks, the scars which appear on a casting if bronze leaks into the space between imperfectly fitted mold sections. In Figure 15 the band of decoration has three discontinuities on the axes where the mold was divided, and it is commonly argued that the flanges seen in Figure 16 were introduced to hide such discontinuities. In other words, the Shang caster is supposed to have made a virtue out of a defect, exaggerating the mold marks and converting them into vertical accents.[8]

This theory, which proposes a specific relationship between technique and design, is open to a number of objections, both general and particular.

Fig. 17. Guang, ca. 12th century B.C. H. 23.5 cm. Courtesy Freer Gallery of Art, Smithsonian Institution, Washington, D.C. (38.5).

It overlooks the actual source of the flange, which is to be found in Neolithic pottery; its mechanical equation of mold marks and flanges disregards the many vessels on which the two do not coincide; and, most seriously, it supposes that the evolution of

Fig. 18. Elephant-shaped zun, ca. 12th century B.C. H. 17.5 cm. Courtesy Freer Gallery of Art, Smithsonian Institution, Washington, D.C. (36.6).

Fig. 19. You, ca. 13th century B.C. H. 30.1 cm. Courtesy Arthur M. Sackler Gallery, Smithsonian Institution, Washington, D.C.

Shang design was influenced by the caster's desire to overcome the drawbacks of a flawed casting technique. The distinctly negative assessment of the section-mold technique on which this last point rests can hardly have been shared by Shang founders, if only because it depends implicitly on a comparison with the lost-wax method. Yet despite general acknowledgement of the intimate connection between the Shang caster's technique and his designs, writers seduced by the theoretical simplicity of lost-wax casting and unaware of its practical difficulties continue to assume that the lost-wax technique offers a better way of casting Shang bronzes than the technique in which those bronzes were invented.[9]

If it could be shown that a Shang founder ever used flanges to save a casting from disfigurement by mold marks, we would indeed be forced to conclude that his designs were influenced by shortcomings inherent in his technique. But the testimony of surviving bronzes, flanged and unflanged alike, is that Shang casters saw no connection between mold marks and flanges. Consider first a vessel without flanges, the guang of Figure 17. It is obvious that the maker of this vessel was concerned to avoid or eliminate mold marks; it is also obvious that his way of dealing with mold marks did not involve flanges. The existence of technically fine unflanged castings is difficult to reconcile with any theory which describes flanges as the solution to a pressing technical problem.

The testimony of vessels which do carry flanges is no different. The elephant-shaped zun shown in Figure 18 has several flanges, but there is no reason to believe that they have anything to do with hiding mold marks. They were added, in locations where mold marks could easily have been ground away, to draw attention to the curve of the elephant's trunk and tail. Other mold divisions fell at locations less accessible to the finisher, yet those locations were not supplied with flanges: if the Shang caster had been in the habit of using flanges to save his decoration from disfigurement, it is on the elephant's hindquarters that we should expect to find them. As in the case of the guang, however, the omission of flanges could hardly be said to have left this vessel disfigured. It is not difficult to find where the mold joins fell, but only a twentieth-century observer would look for them.

The you of Figure 19 is more regular in shape than the guang and the elephant zun, and thus more typical of Shang bronzes, but it shows no more sign of a connection between mold marks and flanges. The only flange is on the swing handle, where it

Fig. 20. Unflanged zun from Zhengzhou Baijiazhuang M3, ca. 14th century B.C. H. 27.7 cm. After *Henan chutu Shang Zhou qingtongqi*, no. 33.

Fig. 21. Flanged zun from Zhengzhou Renmin Gongyuan, ca. 14th century B.C. H. 24.9 cm. After *Henan chutu Shang Zhou qingtongqi*, no. 76.

cannot have been meant to conceal a mold mark; it serves instead to draw attention to the curve of the handle, which repeats the shape of the vessel proper. The vessel is intricately decorated, and though at least four vertical mold divisions must have been required to release mold from model, it is unflanged. Here as on the guang and zun, flanges and mold marks lead independent lives. Flanges were added wherever the caster felt the need of a vertical accent or wanted to dramatize a silhouette.

The objects shown in Figures 17–19 are among the most lavishly decorated of Shang bronzes, and the guang and zun are moreover unusually complicated in shape. Few vessels can have posed greater technical difficulties at the moldmaking stage, but the difficulties were resolved without the use of flanges. Such examples make it clear that Shang founders did not automatically add a flange everywhere a mold division fell, and the examples could be multiplied indefinitely. Yet numbers alone will not disprove the theory that flanges and mold marks are connected, because it might still be argued that *in the beginning* the flange was a device for hiding mold marks. In other words, the fact that the flange was at some stage used as a design element does not rule out the possibility that the design element originated as a device for hiding mold marks.

To deal with this possibility we must turn to the earliest flanged bronzes. The flange made its first appearance shortly before the Anyang period, around the end of the Erligang phase. The unflanged vessel shown in Figure 20 dates from that time. To judge from its decoration, it is essentially contemporary with the first flanged bronzes, and the decision to introduce flanges must therefore have been taken by casters engaged in producing vessels like this one. The zun illustrated in Figure 21 shows the result of their decision: large curvilinear flanges project from the decorated registers on the axes of the vertical mold divisions.

If flanges were added to conceal mold marks, as the prevailing theory maintains, we must believe that a caster found the mold marks on the vessel of Figure 20 so disturbing that he added the flamboyant devices seen in Figure 21 to hide them. Surely just the opposite is true. The caster who made the vessel of Figure 20 had no need to hide mold marks; it takes an expert to find any trace of mold marks. What mattered to the caster was to clarify the organization of his design at a time when the growing intricacy of the patterns had begun to make the dividing lines between compartments difficult to find. His problem was not to hide flaws but to emphasize boundaries. The motive which prompted the introduction of flanges was not concealment but advertisement.

Fig. 22. Gui from Hubei Huangpi Panlongcheng, ca. 14th century B.C. H. 17.4 cm. After Bagley, *Shang Ritual Bronzes in the Arthur M. Sackler Collections,* fig. 214.

Another unflanged vessel of about the same time appears in Figure 22. The rubbing of the decoration shows immediately where the mold was divided. The vertical line at that point was important to the Shang caster because it separated two units of decoration. Most writers on Chinese bronzes have fallen into the habit of calling this line a mold mark, but is that really correct? If we use the term "mold mark" to mean a line that the caster would like to eliminate, then this is not a mold mark. Neither are the horizontal lines above and below the band of decoration. None of these lines is accidental; all of them could have been removed. The vertical line is not an unfortunate by-product of the casting process, it is an essential part of the decoration. When intricate patterns threatened to overwhelm such boundary lines, the caster marked them with the heaviest accent he could find—as in Figure 21.

But where did the Shang caster find this particular accent? The prevailing theory holds that the flange is simply an extravagantly enlarged mold mark, but it cannot explain why the enlarged mold mark takes the distinctive hooked form seen in Figure 21, and the hooked profile of the earliest flanges is in fact the key to their ancestry. The same profile appears regularly on the legs of a common early bronze vessel type, the flat-legged ding tripod (Fig. 12), and such tripods copy in metal a shape which originated at least two thousand years earlier in Neolithic pottery. Typical of the most archaic Neolithic versions of the shape is a pottery ding from an east-coast site of the fourth millennium B.C. (Fig. 23). The flat legs of the Neolithic vessel are radially placed, and by way of embellishment their outer edges are pinched or serrated. Legs embellished in this way remained a feature of the

flat-legged ding shape throughout its history. Pottery examples with serrated flat legs have been found at Erlitou and other early Bronze Age sites (Fig. 24), and the first flat-legged ding in bronze are faithful copies of the pottery vessels (Fig. 12). The pottery tripod shown in Figure 24 is contemporary with the primitive bronze jue vessels from Erlitou and only a little earlier than the Erligang-phase bronze tripod of Figure 12. The bronze ding reproduces the pottery shape in metal, and it preserves and exaggerates the jagged outline of the leg.

Recall how the mold for such a flat-legged tripod was divided (Fig. 13). The divisions were aligned with the legs of the model so that the legs would not hinder the removal of mold from model; each leg left its imprint in the lateral faces of two adjacent mold sections. Since the breaks in the band of decoration also coincided with the legs and the mold divisions, a flange could be introduced between two adjacent units of decoration merely by extending the curly part of the corresponding leg upward.

Thus the flanges seen in Figure 21 have a curly outline because they copy the serrated legs of flat-legged tripods. An embellishment which could be added to the leg of a tripod could be added at the mold joins of any vessel type. From a technical point of view, the leg on the ding and the flange on the zun are equivalent features; the flange is merely a leg that does not reach to the bottom of the vessel. From an artistic point of view, the flange supplies heavy emphasis just where it is needed most, at the vertical break between pattern units.

If we consider for a moment only the early history of the flange, how should we go about describing the relationship between this design element and the caster's technique? The two things are certainly related, but the relationship is not at all simple. Flanges have nothing to do with mold marks; they were added to stress vertical divisions in the decoration, and when they lie at mold join lines it is only because the mold join lines are the boundaries between units of decoration. In other words, flanges were not added for technical reasons, they were added for reasons of design. But what made their addition desirable was the compartmented character of Shang decoration, and that character owed its existence to a series of experiments with a particular casting technique.

The history of the flange is evidence enough that the formulation "technique influenced design" would be a very misleading description of the events which make up the history of Shang bronze casting. Certainly if Shang casters had for some reason chosen to use the lost-wax method, Shang bronzes would look very different. Yet if we ask how the section-mold technique *influenced* vessel design, we too easily fall into the habit of regarding the technique as a known quantity, fixed and unalterable, which actively modified the caster's intentions; we imagine that the caster was forced by the limitations of his technique to some sort of compromise with his original idea. But the notion of artistic ideas conceived in the abstract and then imperfectly realized in matter is an irrelevant importation from Renaissance art theory. A Shang caster would probably be puzzled to hear that his technique had limitations. The section-mold technique did not force him to produce compartmented decoration, nor did it force him to use flanges or to carve sharp-edged lines. We will understand the bronzes better if we think in positive rather than negative terms. The caster saw possibilities, not limitations, and the history of Shang bronzes is the history of his exploration of the possibilities of the section-mold technique.

Fig. 23. Pottery ding from Shanghai Qingpu Songze (middle level), 4th millennium B.C. H. 31.7 cm. After Feng Xianming et al., *Zhongguo taoci shi* (Beijing, 1982), pl. 7:3.

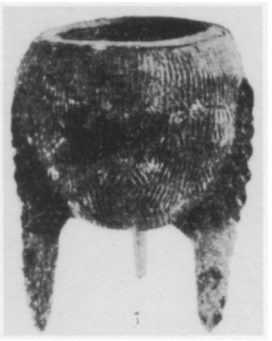

Fig. 24. Pottery ding from Luoyang Donggan'gou, first half of the 2nd millennium B.C. After *Kaogu* 1959.10, pl. 7:1.

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Notes

1. Orvar Karlbeck, Anyang Moulds, *Bulletin of the Museum of Far Eastern Antiquities, Stockholm* 7 (1935): 39–60.

2. The direct lost-wax method described here is today seldom used because it does not allow duplicate castings and because of the risk involved in destroying the original model. The indirect lost-wax method, employed in Greek foundries as early as the seventh century B.C., preserves the original model intact by forming a section mold on it and then using the section mold to produce a wax model or models. See Ruth Whitehouse, *The Macmillan Dictionary of Archaeology* (London, 1983), p. 112; Christian Hauser, *Art Foundry* (New York, 1974); Carol C. Mattusch, *Greek Bronze Statuary* (Ithaca, N.Y. 1988).

3. For no obvious reason, models seem never to have been reused by Shang founders; duplicate castings are unknown among Shang bronzes (see R. Bagley, *Shang Ritual Bronzes in the Arthur M. Sackler Collections*, Cambridge, Mass., 1987, introduction, section 2.2). Molds ordinarily are too much damaged in removal from a casting to be used again.

4. J. Leroy Davidson, Toward a Grouping of Early Chinese Bronzes, *Parnassus* 9.4 (April 1937): 29–34, 51. Davidson cited not the tripod of Figure 7 but a similar vessel formerly in Berlin.

5. Of these the most notable was Shi Zhangru, whose comprehensive study of the Shang bronze industry dates from 1955: Yin dai de zhu tong gongyi, *Zhongyang Yanjiuyuan Lishi Yuyan Yanjiusuo jikan* 26 (1955): 95–129.

6. Rutherford John Gettens, Joining Methods in the Fabrication of Ancient Chinese Bronze Ceremonial Vessels, *Application of Science in Examination of Works of Art* (Museum of Fine Arts, Boston, 1967), pp. 205–217. The subject is treated more extensively in the same author's *The Freer Chinese Bronzes, Volume II, Technical Studies* (Washington, D.C., 1969).

7. Wilma Fairbank, Piece-Mold Craftsmanship and Shang Bronze Design, *Archives of the Chinese Art Society of America* 16 (1962): 8–15. Noel Barnard's *Bronze Casting and Bronze Alloys in Ancient China* (Tokyo, 1961), a more speculative account of section-mold casting, makes no explicit mention of the connection between technique and design. Among later writings on the subject, the papers reprinted in Cyril Smith's *A Search for Structure* (Cambridge, Mass., 1981) should be singled out for their illuminating comments on the relationship between technology and artistic invention.

8. This interpretation, which seems to have originated with Noel Barnard and Wilma Fairbank, has been very widely accepted. Barnard (*Bronze Casting*, p. 117) included flanges on a list of expedients for dealing with mold marks; Fairbank (Piece-Mold Craftsmanship, pp. 12–13) described them as a design element "evolved from the practical requirements of craftsmanship."

9. Fairbank's 1962 paper (pp. 9–10) attributes an unqualified superiority to the lost-wax method. The same assessment is implicit in William Watson's discussion of Shang metal technology (*Cultural Frontiers in Ancient East Asia*, Edinburgh, 1971, pp. 72–79), to cite a more recent example, and it forms the cornerstone of Noel Barnard's oft-repeated argument for the independent origin of Chinese metallurgy: in Barnard's view, if Chinese casters had known of the lost-wax process, they would never have used section molds (see e.g. *Monumenta Serica* 22, 1963, pp. 225–227). Perhaps the confusion arises ultimately from comparing textbook abstractions (*the* section-mold process, *the* lost-wax process) rather than actual casting techniques. Most writers who discuss "the section-mold process" understand by that term a procedure far simpler than the one used to cast the four-ram zun of Figure 10, and few seem to be aware that the procedures commonly referred to as "the lost-wax process" often involve section molds (see note 2 and Bagley, *Shang Ritual Bronzes*, introduction, section 2.6).