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TRADITIONAL IRON-WORKING IN CENTRAL AFRICA WITH SOME REFERENCE TO THE RITUALISTIC AND SCIENTIFIC ASPECTS OF THE INDUSTRY *

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THE ARCHAEOLOGICAL AND metallurgical features of African iron-working have been studied in depth,[1] and research has been conducted on the economics and demography of the industry.[2] Yet there is little more than incidental concern with the accompanying ritual and none at all with the scientific implications. An otherwise authoritative writer has complained of a regrettable result due to 'a tendency to follow the views of an earlier school of archaeologists and anthropologists who regarded iron-working as an economic ritual controlled by the need for secrecy, sexual taboo and exotic mystery'[3] — a statement which I consider to be unfortunate in suggesting that traditional iron-smelting and forging need not be explained in terms of ritual. Believing that in a study of traditional industries the ritualistic features cannot be divorced from the mechanical descriptions of processes, the following is a very general paper on traditional iron-working but with more emphasis on the ritual and on the possible scientific interpretations of this industry. The paper is, therefore, divided into the following sections:

A brief history of iron-working in Africa.
Two contrasted methods of iron extraction in Zambia and Rhodesia.
The ritualistic aspect.
The scientific aspect: practical and theoretical considerations.
Conclusion.

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1 W. Cline, *Mining and Metallurgy in Negro Africa* (Menasha, Wis., Banta, 1937): a good summary but with little reference to Southern Africa; R. F. Tylecote. *Metallurgy in Archaeology* (London, Arnold, 1962); S. V. Pearce, *The Appearance of Iron and Its Use in Protohistoric Africa* (no details, mimeo : based on Univ. of London M.A. thesis, 1960).

2 J. M. MacKenzie, 'A precolonial industry: The Njanja and the iron trade', *NADA* (1975), XI ii, 200-20.

3 M. D. Prendergast, 'Research into the ferrous metallurgy of Rhodesian Iron Age societies', *Journal of the South African Institute of Mining and Metallurgy* (1973-4), LXXIV, 254-5.

A BRIEF HISTORY OF IRON-WORKING IN AFRICA

Although the metal iron never possessed the charismatic property of gold, it was, nevertheless, a symbol of inexplicable and stupendous preternatural power. Did not the first native iron arrive dramatically from the sky where it was possibly associated with thunder and lightning as well as the unpredictable falling of stars? A Hittite text of the fourteenth century B.C. speaks of 'black iron of heaven from the sky',[4] and as late as the close of the nineteenth century the Bedouin of Sinai believed that a man who succeeded in forging a sword of meteoric iron was invulnerable in battle.[5]

There appears to be no legendary history of the discovery of man-made iron although it is possible that Pliny's account of the discovery of glass is analogous. A ship's crew is said to have made a fire on a sandy beach in Phoenicia and supported their cooking pots on lumps of native soda which were a part of the cargo. It is possible that nodules of iron ore, usually iron sulphide, were part of a vigorous camp fire, and as a temperature of 700°-800°C is possible in a small hole in the ground without the aid of an artificial blast, it is likely that small pieces of wrought iron were produced in this manner for the first time. The original use of the metal is believed to have occurred in the first half of the third millenium B.C. in Egypt and the Near East where iron beads were made from meteoric iron,[6] but man-made iron probably appeared between 1900 and 1400 B.C. Not until it could be produced as a mild steel was it of great use; this was accomplished by further heating wrought iron to which charcoal was added.

The Kushites, in the seventh century B.C., abandoned lower Egypt to an Assyrian army equipped with iron weapons, and established themselves at Meroe in Nubia where there were ample supplies of iron ore and wood which maintained an iron industry from the fourth century B.C. to the fourth century A.D.[7] The diffusion of smelting and forging techniques from the Sudan to southern Africa is still a subject of controversy and one which is fraught with difficulties owing to the corrodable nature of iron, especially in acid soils. Direct evidence of iron-working is usually revealed by the presence of slag, which being a silicate is indestructable, and by curved fragments of furnace wall together with the remains of broken baked clay pipes, or tuyeres, which were part of induced-draught furnaces where air entered at the bottom of the furnace. The diffusion of iron-working may have followed two routes; westward from the Nile valley to the Chad region in the

[4] J. W. Mellor, *A Comprehensive Treatise on Inorganic and Theoretical Chemistry* (London, Longmans Green, 12th edit., 1957), 483.

[5] M. Eliade, *The Forge and the Crucible* transl. S. Corrin (London, Harper and Row, 1962), 27, citing W. E. J. Bramley, *The Bedouins of the Sinai Peninsula* (London, Palestine Exploration Fund, 1906).

[6] Pearce, *The Appearance of Iron*, 9, 28.

[7] A. J. Arkell, 'The Iron Age in the Sudan', *Current Anthropology* (1966), VII, 451.

first few centuries before and after the birth of Christ, from whence the techniques travelled south and west; or southwards from Libya where the Berbers, who had learnt iron-working in the Sudan, passed on their skills to West African peoples and thence southwards again to those of the savannahs and the tropical forest.[8] Vague references to the iron mines in the hinterland of Sofala were made by Ibn'al-Wardi of Cairo in 1340[9] and even earlier by Edrisi of Sicily in the twelfth century.[10]

The disappearance of the industry in the first two decades of this century may be ascribed to reasons which are commercial, humanitarian and political. The introduction of factory-made imported steel articles contributed largely to its decline. Thereafter, the iron-worker dispensed with the arduous task of constructing a furnace although forging continues to this day from scrap metal such as the leaves of car springs. The factory-made hoe is not as susceptible to rusting because it is fashioned from a homogeneous cast steel whereas the traditional hoe contained areas of wrought iron, slag and several grades of mild steel which, in the presence of water charged with atmospheric carbon dioxide, gave rise to those electrochemical reactions whose end-product is rust.[11] The humanitarian reason concerns the ban on the use of goat-skin for the bellows[12] which was obtained by flaying the animal whilst alive. It was believed that the most efficient bellows were obtained from goats which survived this ordeal until nightfall.[13] Although the flaying of live goats was forbidden in Rhodesia from 1897 the use of imported factory-made hoes may have encouraged the abandonment of this practice. The political reason arose from the manufacture of bullets from locally forged iron rod which were fired from rifles brought from Kimberley by Africans returning from the diamond mines. Gunpowder was locally manufactured from the faecal droppings of the Rock Dassie *(Procavia capensis)* or its dried urine found in caves, both of which contain saltpetre. These were mixed with charcoal or slag, the latter probably containing residual charcoal. With the extension of colonial rule it was not unexpected that the forging of bullets was discouraged by the confiscation of guns,[14] although iron-working at Hwedza, Rhodesia, had already been banned by two neighbouring District Commissioners. Thus, the industry which gave its name to a widespread culture came to an end and only the occasional exhibition by surviving members of smelting families enables us to speculate

[8] Pearce, *The Appearance of Iron*, 12-13, 75.
[9] H. Salt, *A Voyage to Abyssinia* (London, Rivington, 1814), 57.
[10] G. Ferrands, 'Sofala', in *The Encyclopaedia of Islam* (Leyden, Brill, 4 vols and supplements, 1913-38), IV, 470.
[11] G. H. Stanley, 'Some products of native iron smelting', *South African Journal of Science* (1931), XXVIII, 131.
[12] J. H. Chaplin, 'Notes on traditional smelting in Northern Rhodesia', *South African Archaelogical Bulletin* (1961), XVI, 60.
[13] J. S. Hatton, 'Notes on Makalanga iron smelting', *NADA* (1967), IX, iv, 40-1.
[14] MacKenzie, 'A pre-colonial industry', 218.

on the former Hwedza countryside, described by an English missionary in 1893 as 'the Wolverhampton of Mashonaland', a Black Country in which every village had several forges.[15]

TWO CONTRASTED METHODS OF IRON EXTRACTION IN ZAMBIA AND RHODESIA

The principle of traditional iron extraction is basically the same as that of modern industrial extraction because it consists of heating strongly a mixture of iron ore and carbon. It is the reduction of an ore which is actually, or potentially, an oxide of iron, with charcoal. The reaction inside the furnace can be simply expressed as

Iron oxide + Carbon = Iron + Carbon dioxide

— perhaps too simply stated because an intermediate stage is the formation of carbon monoxide gas which is the effective reducing agent.

For the purpose of this paper iron-working techniques can be divided into those where shaft furnaces were employed, as in Zambia, and those in which the smaller 'beehive' furnaces were used as in Rhodesia. I have omitted the more primitive 'open bowl' or 'pit' type of furnaces as used in pre-Roman Britain and found in various parts of Rhodesia, such as Inyanga[16] and Khami, which suggest an earlier technique for which there is no evidence of ritual. That the shaft furnace was a development of the pit furnace is shown by the Roman introduction into Britain in the second century of a furnace which was no other than the pit type with its sides built up to a height of just over one metre and blown by induced draught, whereas in the simple pit furnace bellows were used.[17]

The shaft furnace, typical of Africa north of the Zambezi, has been carefully documented from an example in south-west Tanzania where the height was about 3 metres, the diameter increasing from 0.75m at the top to 1.5m at the bottom, the walls having a uniform thickness of 13cm.[18]

Although the custom was often relaxed, smelting was generally a family skill, a new shaft furnace being constructed when a young member of the family was considered physically suitable to pursue the trade. His skilled relatives constructed a new furnace with clay, inside of which the

[15] I. Shimmin, 'Journey to Gambisa's', in F. W. McDonald, *The Story of Mashonaland and the Missionary Pioneers* (London, Wesleyan Mission House, 1893), 51, 55.

[16] R. Summers, *Inyanga*, (Cambridge, Univ. Press, 1958), 61, 114.

[17] Tylecote, *Metallurgy in Archaeology*, 220. However, the pit furnace, although a poor heat conserver, could be used for the rapid smelting of successive charges of ore and charcoal without breaking down a part of the furnace as in shaft and beehive types, but as the slag was not tapped it was necessary to remove it before smelting could be repeated.

[18] B. P. Brock, 'Iron working amongst the Nyiha of south-western Tanganyika', *South African Archaeological Bulletin* (1965), XX , 98.

apprentice stood until it was at a height which he could just reach. A pole was placed over the top opening and the relatives, supported on a scaffolding, would raise him very carefully out of the furnace because it was a bad omen if any of the soft clay was disturbed during this ritual. Once outside the furnace he danced and sang, 'Now I am grown up I am taller than the thatching grass'. He was then entitled to call himself *n'anga* (doctor), and was alone responsible for the stacking of firewood, iron ore and charcoal when smelting was about to start, and also responsible for starting the furnace fire. Before the clay of the furnace had dried, a cockerel's head was chopped off by the senior 'doctor' and the blood sprinkled over the walls of the furnace to ensure that it would not crack or collapse during smelting.[19] The clay-pipe tuyeres, or air pipes, of 5-10 centimetres diameter which allowed air to enter the bottom of the furnace, were prepared by men although pottery was normally a woman's trade.[20] To ensure an efficaceous draught a furnace would have from 40 to 80 tuyeres.

The ore was either a haematite (ironstone) consisting mainly of ferric oxide, or limonite (bog iron), a hydrated ferric oxide found around the edges of marshy depressions. There appear to have been no taboos in the mining and transportation of ore, and the absence of women from open-cast mining may have been for physical rather than ritual reasons. Ore deposits were sought by the older men after which young men were sent to excavate while women assisted in transporting ore to the furnace site in oval baskets carried on their heads or on the backs of oxen.[21] Pulverizing of the ore was effected by roasting, prior to which the ore was upgraded by hand-picking.[22] Charcoal was obtained by burning logs from trees selected for their hard timber, broken up with rakes and carried by women to the furnace in baskets.[23]

The careful stacking and firing of the furnace might suggest that these precautions were necessary to avoid the effects of counter-magic by a rival smelter, yet there is never any mention of such sorcery, perhaps because of the smelter's prestige; it was he who knew the 'medicines' necessary for success. These were mainly preventitive, countering the disastrous effect

19 W. V. Brelsford, 'Rituals and medicines of Chishanga ironworkers', *Man* (1949), XLIX, 27-9.

20 H. B. Barnes, 'Iron smelting among the ba-Ushi', *Journal of the Royal Anthropological Institute* (1926), LVI, 190.

21 G. Kay and D. M. Wright, 'Aspects of the Ushi iron industry', *Northern Rhodesia Journal* (1962), V, 30-1.

22 R. F. Tylecote, 'Iron smelting in pre-industrial communities', *Journal of the Iron and Steel Institute* (1965), CCIII, 340.

23 MacKenzie, 'A pre-colonial industry', 214, mentions the Hwedza trees used for charcoal burning, *mushava (Monotes glaber)*, *mukarate (Burkea africana)* and *myange (=muvanga?) (Pericopsis angolensis)*. E. Mambaiye, of the Gwelo Teachers' College, includes all these with the addition of *mupembere (Combretum molle)*, 'Kucherwa Nekupfurwa Kwesimbi Kare' (unpubl. essay).

of the presence of menstruating women, or of men who had recently indulged in sexual intercourse, or even of those married unlawfully according to local custom. But counter-magic, interfering with the production of hoes, and therefore food, could not have been tolerated. Even the members of the smelting crew were forbidden sexual intercourse during the period of smelting; they slept by the furnace while their wives were regarded as temporary widows, a male 'wife' being employed to cook for the smelters. The central belief was that the furnace was a symbol of woman kind who gives birth to iron which can be fashioned into implements of war or agriculture, providing protection from enemies and ensuring an adequate sustenance. The furnace was the 'wife' of the smelters while iron production was in progress and therefore sexual intercourse was regarded as adultery. Purification rites were then obligatory, or medicines were placed in the furnace before firing. As miscarriages and still-births were attributed to the unfaithfulness of the husband, so sexual intercourse could result in a smelting failure where most of the iron was found not in the furnace but in the molten slag which flowed from it, an analogy with menstrual blood.[24] Slag was truly a waste product; it found no use, not even as a fertilizer, and was referred to by the Ngoni of Malawi as 'faeces'.[25] Iron smelting was an anthropocentric ritual analogizing production as reproduction. As with other traditional projects the success of the undertaking depended partly on skill but also on the approval and acquiescence of the ancestral spirits to whom prayers were addressed before mining commenced, before a furnace was constructed and before firing a furnace. Sometimes it was the spirits of former smelters who were petitioned.[26] An interesting compromise is recorded during the 1939-45 wartime revival of iron-working in Zambia, due to a shortage of hoes, when a smelter led in prayer the children from a local mission school.[27]

Rhodesian iron-working was similar in principle to that of Zambia but it was distinguished by the type of smelting furnace used. Whereas the Zambian furnace was a tall induced-draught kiln, the Rhodesian 'beehive' furnace was a smaller forced-draught unit about one metre high. Although smelting in Zambia was effected in an induced-draught furnace, the subsequent forging employed a smaller forced-draught furnace using drum-bellows which were constructed by stretching an animal skin over a clay or wooden bowl. In Rhodesia both the smelting and the forging furnace used a forced draught supplied by goatskin bag-bellows. Reproductive symbolism in Rhodesian iron-working was emphasized by moulding stylistically the clay furnace as a woman about to give birth, with breasts, tribal cicatrices

[24] Kay and Wright, 'Aspects of the Ushi iron industry', 36.
[25] S. N. Stannus, 'Nyasaland: Angoni smelting furnace', *Man* (1914), XIV, 131-2.
[26] Barnes, 'Iron smelting among the ba-Ushi', 192.
[27] Chaplin, 'Notes on traditional smelting', 54.

or *nyora,* umbilicus and genital organs. The goatskin bag-bellows and clay pipe tuyere represented testicles and penis and thus, again, iron smelting analogizing production as reproduction.

Although it appears that the production of iron implements was generally for local use there were certain export centres. It can be readily assumed that the larger production of iron in the shaft furnaces of Zambia implied an export market but more definite evidence concerns the Hwedza industry of Rhodesia where a labour-intensive organization successfully exploited the rich haematite reefs of Hwedza mountain, although this source was in enemy territory belonging to the Mbire tribe. Iron ore was also exported, not only from Hwedza but from Shamva and Mangula *(mhangura* = iron ore), but it was among the Njanja tribe, near Hwedza mountain that there evolved in the eighteenth and nineteenth centuries an industry described as the 'Wolverhampton of Mashonaland'. The missionary who coined this phrase arrived at Gambisa's kraal with a broken clasp on the end of the disselboom, the pole to which the oxen were harnessed. That the clasp was repaired showed that the Njanja were adept at welding and drilling holes in iron.

The construction of a 'beehive' furnace was well described after an exhibition of iron-working in the grounds of the Queen Victoria Museum, Salisbury, in 1944, superintended by Chief Ranga of the Njanja tribe.

> Ranga first dug a circular trench as a foundation; from this he piled up the clay into a conical shape, resembling a female torso bearing tribal markings. This was built up as a solid mass during the day and left to set and dry overnight. The next day a stick was carefully put down the centre from the top for slowly hollowing out the inside. Ranga then burrowed underneath the cone and shaped the hearth, which was hollowed out well below the base. For the next few days a small fire was kept going in the fresh-made furnace, to dry out the clay. Ranga was careful not to mould the inside too quickly in case it collapsed.[28]

It has been alleged, with some justification, that at some such exhibitions the result of the smelting was invariably a lump of poorly reduced iron or 'bloom', or a total failure. The photographs accompanying the article from which I have quoted show clearly the successful production of adzes, spearheads and hoes. Yet at the Witwatersrand Agricultural Society's show at Johannesburg in 1930 when an Njanja smelting crew from Hwedza was performing, it was recorded that the bloom was unrecognizable as iron, having charcoal and slag enmeshed in its cellular structure. Many reheatings and forgings were required before implements could be fashioned from it.[29]

[28] E. G., 'Iron smelting and smithing in Africa', *The Outpost* (1944), XXI, vii, 25-6.

[29] Stanley, 'Some products of native iron smelting', 132.

The Hwedza industry produced hoes, knives, axes, adzes, spear-heads, razors, chiefs' badges, hooks, needles, arm and leg bands, bullets, and a great speciality was the manufacture of the musical instrument, the *mbira*. Production was followed by marketing over a radius of 100 kilometres, the salesmen returning with cattle in exchange for hoes. Both cattle and hoes were used as *rovora* or *lobola* (bride-wealth).

Evidence of any transition from the Zambian induced-draught furnace to the Rhodesian forced-draught furnace, or vice versa, is slender. Chilundu smelters at Kalobo in Zambia worked ore deposits until 1948 when the ore pits were flooded by a rising water table. From a brief description and a photograph it appears that the smelters had used a large beehive-type furnace with drum-bellows, the furnace bearing feminine symbolism, breasts, etc.[30] The Ushi, also of Zambia, were prepared to change from induced-draught furnaces to forced-draught types but abandoned the measure when the flaying of goats was banned, although the importation of cast steel hoes appears to have been the deciding factor in abandoning the industry. But it is clear that the induced draught furnace not only avoided the ban on goat flaying but required less labour during smelting.[31] The Kaonde of Zambia in the early 1920s were shown the superiority of bag-bellows over drum-bellows but they refused to adopt the new device for fear of arousing the anger of their ancestral spirits.[32] The shaft furnace was the typical smelting furnace north of the Zambezi, examples being found not only in Zambia but in Malawi, Zaire and Tanzania, and further north from the Horn of Africa to the Niger delta.[33] It is believed that the forced-draught 'beehive' furnace was introduced to Rhodesia by a fairly recent immigration of Njanja from Moçambique in the eighteenth century.[34]

The accounts of strange peoples supplied by explorers, traders and missionaries, upon which nineteenth century ethnology was founded, have been criticized for being too descriptive and insufficently interpretative. The same criticism might be levelled at what, so far, I have written, and therefore I shall conclude this very necessary description and proceed to a more interpretive phase in discussing the ritualistic and scientific aspects of this subject.

THE RITUALISTIC ASPECT

Just as in the pre-Enlightenment, pre-seventeenth century Europe, the alchemists' experiments depended much on the mental condition of the practitioner, so the ritualistic aspect of the smelter's work, the blacksmith's

[30] J. Housden and M. Armor, 'Indigenous iron smelters at Kalobo', *Northern Rhodesia Journal* (1959-61), IV, 135-8.
[31] Chaplin, 'Notes on traditional smelting', 58.
[32] F. H. Melland, *In Witch-Bound Africa* (London, Seeley Service, 1823), 137.
[33] Pearce, *The Appearance of Iron*, 16.
[34] MacKenzie, 'A pre-colonial industry', 203, 211.

work and the smelting process appeared one and the same subject, but it is simpler to deal separately with these three topics.

Generally, the smelter was much respected and often feared because sometimes he was not only a smelter but also a chief or senior headman by virtue of a large family following owing to his ability to maintain numerous wives, acquired by hoes, the fruits of his skill.[35] There were exceptions such as the Masai of Kenya where God offered Man a herdsman's staff, a bow and a smith's hammer. The poor smith was left with the hammer as the other gifts were claimed by the ancestors of pastoral and hunting tribes. Or, their neighbours, the Suk, who pity the smiths among them because God gave them only brains but no sheep. Yet the Chagga in the same area believe that marriage to a smith's daughter by an outsider brought him to an early grave, such was the dangerous potency of smith's blood.[36] Smiths and smelters were synonymous in these cases and therefore they have been mentioned in this section devoted to smelters.

Not all smelters were diviners or *n'anga;* often the Rhodesian smelter had his own special *n'anga* who was called upon to guarantee the success of the smelting operation. The *n'anga* would speak on the work to be accomplished that day and comment again at the end of the day. Sometimes 'medicines' would be administered orally to the smelters and a goat sacrificed to the Great Earth Mother, *Zimai-revhu,* or *Zimai-remhangura,* the Great Iron Mother, who must not be offended. Where this deity stood in the hierarchy of spirits is not clear. The goat, consumed by the smelters, ensured a successful fire in the furnace.[37] The Ila of Zambia obtained the same result by what Frazer would have termed homeopathic magic. Their furnace 'medicine' consisted of a piece of hippopotamus hide and some guinea-fowl feathers because a successful fire simulates the cries of hippo and guinea-fowl.[38]

Reading through the literature on iron-working one is surprised by the rich mythology of smithing compared with that of smelting. The confusion in some reports between the smith and the smelter may partially account for this discrepancy but I may suggest that the social status of each accounts for the difference. The smelter was a skilled worker as well as a chief and little or no additional prestige was needed. But there were smiths in every village and they were only associated with the metal itself, whereas the smelter was concerned with the actual birth of the metal inside its mother, the furnace. The smith perhaps needed a mythological boost.

[35] G. Dieterlen, 'A contribution to the study of blacksmiths in West Africa' in P. Alexandre (ed.), *French Perspectives in African Studies* (London, Oxford Univ. Press, 1973), 40; MacKenzie, 'A pre-colonial industry', 207.

[36] Cline, *Mining and Metallurgy,* 114, 115.

[37] Mambaiye, 'Kucherwa Nekupfurwa Kwesimbi Kare'.

[38] E. W. Smith and A. M. Dale, *The Ila-Speaking Peoples of Northern Rhodesia* (London, Macmillan, 2 vols, 1920), I, 210.

Whereas the smelter, except for exhibition purposes, has all but disappeared from the African scene, the blacksmith has survived because of his ability to effect repairs and to forge implements from scrap iron. Teachers in African schools will recollect woodcarving classes where each pupil brought his own locally made adze, forged from a leaf of a discarded car spring. It was among the Dogon of Mali that the prestige of the smith found its zenith which can be told briefly as follows. The Creator of the world, Amma by name, 'found' a 'womb' to receive his sperm from which issued two sets of 'fraternal' or two-egg twins, Igo and his sister Yasa, and Nommo with his brother who is never named is referred to as the Blacksmith. Ogo committed incest with his 'mother' for which he was transformed into a fox, representing all that is evil, including drought, sterility, disorder, impurity and death, whilst Nommo stood for fertility, order, purity and life. Amma took the heart-blood of Nommo and threw it to Earth where it landed upside down as an anvil. The anvil miraculously rose again and embedded itself in the ground the right side up. Today, whenever a Dogon 'plants' his anvil in a shelter he is acting out this part of the legend. Nommo had already been castrated and his penis and testicles were thrown to earth to act as blast-pipe and bellows. But the Blacksmith had yet to learn the art of obtaining iron from ores; therefore Amma threw down the blood of Nommo's spleen which changed to a lump of iron, recognizable as a meteorite. It was now Yasa's turn to be useful when an arm was amputated to provide a hammer and the hand became a pair of pincers.[39] No similar legend appears to exist in central Africa, but then the Dogon are a remarkable people with an exceptional cosmogony. Anxiety for the success of blacksmithing, with its consequences in hoe manufacture and therefore in food production, was a feature among the Ondulu of south-east Angola. When the large blacksmith's hammer, or sledge hammer, was forged it was tied to the back of a young girl with a cloth, as a baby is tied to its mother. It was carried thus to the waiting villagers who welcomed it with appropriate songs. The hammer received the name of the Chief because it was the provider of food, for without it no hoes could be forged and therefore no crops could be cultivated.[40] Yet on the whole, the blacksmith exercised a secular function in the community; preternatural forces did not go beyond the smelting process.

If there are two general characteristics of smelting ritual throughout Africa they are the deep abhorrence of the presence of menstruating women, and secondly, the injunction to the smelting crew to abstain from sexual intercourse during the period of smelting. However, it appears that when increased production was required for export, as in the case of the Njanja of Hwedza,

[39] Dieterlen, 'A contribution to the study of blacksmiths', 41.
[40] F. W. Read, 'Iron smelting and native blacksmithing in Ondulu country, south-east Angola', *Journal of the African Society* (1902-3), II, 44-9.

there was a relaxation of taboos. Menstrual blood may be only a plasma containing various living corpuscles transporting food, oxygen and waste matter, but ritually it is in that fearsome category between the living and the non-living. Yet it is associated with potential reproduction and therefore it can be regarded as sacred as well as unclean and contagious, giving rise to a prohibition which is a taboo in the fullest meaning of the term. At the furnace a menstruating woman is passing blood, analogous to a running slag which contains most of the iron from the ore so that a very poor bloom is left in the furnace, resulting in a serious waste of ore, charcoal, firewood and time.[41] The taboo on menstruating women also applies to the cattle kraal where it is feared that their presence will encourage the production of still-born or prematurely born calves. But the cattle kraal is family property over which there is a greater measure of control over visitors than in the case of the smelting furnace which, although at some distance from the village, can be visited by all and sundry, by known and unknown women, hence the use of 'medicines'. In the pursuit of effective medicines, use was made of the strongly toxic alkaloid content of certain Amaryllidaceae bulbs or *durura* belonging to several plants referred to as *mushandwe* which flower in vleis in the rainy season. I would suggest that the *mushandwe* commonly used was *Boophane disticha* or Sore-eye because the large fan-like leaves are clearly seen in winter when smelting took place. A more positive approach to 'medicine' was adopted by the Ila of Zambia who claimed that their medicines transformed the ore into iron and that without them the reaction would not proceed.[42] The function of the 'medicines' will be further discussed under scientific aspects.[43]

The magico-ritualistic properties of the human foetus and placenta were recognized by the Tonga of Zambia who cast a piece of the afterbirth into the furnace to improve smelting; and also by the Chewa of Malawi who placed 'medicine' inside a stripped mealie cob which was then thrown at a pregnant woman, resulting in a miscarriage following the shock. A 'doctor' retrieved the foetus from a refuse heap, mixed it with 'medicine' and then burnt it in a hole in the ground over which the furnace was constructed. Some of the hoes thus produced were given to the woman who, so it is said, never knew the reason for the gift.[44] These two examples may refer to an analogy between the embryonic primal substance of the world and the ore used in the earliest metallurgy. Babylonian texts in the library

[41] Kay and Wright, 'Aspects of the Ushi iron industry', 36; the prohibition of menstruating women applies throughout Africa, not only to Zambia.

[42] Smith and Dale, *The Ila-Speaking Peoples*, I, 203.

[43] The emphasis on female taboos appears to have varied in place and time. Ultimately, the labour-intensive industry at Hwedza included the smelters' wives who cooked for their husbands at the furnace site and 'some clever women tried the bellows and became good at blowing them', private communication from Dr J. M. MacKenzie.

[44] Cline, *Mining and Metallurgy*, 119.

of Assurbanipal, king of Assyria in the seventh century B.C. refer to the magical properties of a human foetus added to the smelting furnace[45] but the paucity of such examples in African metallurgy behoves us to adopt a sceptical view towards any attempt to correlate African custom with that of Babylonia, China or even medieval Europe where the analogy between the human foetus and metallic ores was derived from the symbolism of the macrocosm and the microcosm by which man is formed after the image of the cosmos, a hypothesis which does not appear to exist in African society.

THE SCIENTIFIC ASPECT — PRACTICAL AND THEORETICAL CONSIDERATIONS

It had been assumed that the product of African iron smelting was a bloom of wrought iron mixed with siliceous slag, unused ore and charcoal, the impurities being removed by hammering them out of the plastic bloom. Wrought iron was the usual product of British furnaces before their conversion to blast furnaces at the beginning of the sixteenth century when their increased temperature enabled cast iron to be produced. Wrought iron is sometimes described as pure iron although it usually contains carbon up to 0.15 per cent which gives it the properties of mild steel. However, by polishing and acid-etching an iron surface from a traditional furnace, and then obtaining a microphotograph of the surface, it is found to be a heterogenous product containing not only wrought iron but the constituents of steel, i.e. pearlite and ferrite. Usually the microphotograph reveals several grades of steel together with iron and slag, proving that the iron had not been cast. Traces of cast steel are seen, suggesting that very high but localized temperatures were possible.[46] This was confirmed during an investigation of old shaft furnaces in Britain when a specially constructed furnace fitted with temperature measuring thermo-couples at various heights recorded a general temperature of 1,200°C with a maximum temperature of 1,600°C at the base of the furnace, rendering possible the formation of a small quantity of cast iron to be absorbed by the bloom. This work is mentioned because although not entirely relevant to African practice — the furnace was constructed of firebrick blocks and was a shaft furnace supplied with forced draught — it suggests that some cast iron could have been formed in a traditional furnace.[47] Yet what credence can be awarded to eye-witness accounts of molten iron pouring into moulds excavated in the ground? Some testimonies[48] are so extremely doubtful that *mvura yemahwe* (water from

[45] M. L. von Franz, 'The idea of the macro- and microcosmos in the light of Jungian psychology', *Ambix* (1965), XIII, i, 22.

[46] Stanley, 'Some products of native iron smelting', 131-2.

[47] R. F. Tylecote *et. al.*, 'The mechanism of the bloomery process in shaft furnaces', *Journal of the Iron and Steel Institute* (1971), CCIX, 342-63, esp. 344.

[48] Univ. of Rhodesia, Dep. of History, Oral Interviews Collection, J. M. MacKenzie, JM 1/2, Masweru of Chibi, 26 Feb. 1974.

the stones) may refer to molten slag. But there are statements in which the removal of the slag is followed by the release of the molten metal into a mould, although the informants were elders recounting the recollections of juvenile spectators.[49] It is doubtful whether this question will ever be resolved; most of the evidence suggests that a bloom of impure wrought iron was produced, and latter-day demonstrations of smelting confirm this conclusion.[49]

As is generally known, a flux is a substance which combines with the siliceous impurity, or gangue, in an ore to form a silicate which, due to its comparatively low melting point, is free-flowing at the temperature of the furnace so that it can be separated from the bloom as a slag. No flux was employed in pre-Roman Britain with the result that about half the iron was lost in the slag because it combined with the high proportion of silica in the ore. Lime was first added as a flux in the first century A.D. and continued to be used up to the sixteenth century when it appears to have been gradually replaced by limestone, first mentioned as a flux in the mid-seventeenth century.[50] Usually a flux was unnecessary in African smelting where the low silica content of the upgraded ore combined with a little of the high iron content to form a ferrous oxide content which combined with the silica impurity in the ore.[51] Burnt bone, rich in calcium carbonate, has been found near a smelting site at Inyanga,[52] but these are isolated examples when compared with the general use of bones by the Venda of the Transvaal. Human bones were especially sought after, and there was much consternation among the smelters at the 1936 Empire Exhibition in Johannesburg when it was rumoured that their bones were wanted by the Iron and Steel Corporation (Iscor).[53]

The removing, or tapping, of molten slag was generally neglected as there was so little slag which was usually found on the charcoal bed of the furnace when the bloom was removed. However, there is evidence of slag-tapping from shaft furnaces; the Lungu of Zambia fired their furnaces for 26 hours after which molten slag was released through a hole in the furnace at ground level, but it was not until a further 18 hours had elapsed that the bloom was removed and refined in a small open furnace, probably a pit furnace.[54] Again, in the Ushi iron industry, also in Zambia, the slag flowed from some of the tuyeres but precautions were taken to ensure that the

[49] Undoubtedly, smelting expertise varied from place to place and the result would depend on a combination of factors such as furnace construction, furnace charging, the grade of ore, personal smelting skill and the quantity of materials used.

[50] H. R. Schubert, *History of the British Iron and Steel Industry* (London, Routledge and Kegan Paul, 1957), 44, 161.

[51] Hatton 'Notes on Makalanga iron smelting'.

[52] Summers, *Inyanga*, 120-1.

[53] U.S. Kusel, *Primitive Iron Smelting in the Transvaal* (Pretoria, The National Cultural History and Open-Air Museum, Studie No. 3, 1974), 5.

[54] Chaplin, 'Notes on traditional smelting', 54.

tuyeres were not blocked[55] as happened at the 1972 Njanja demonstration at Enkeldoorn, Rhodesia, when the blow-pipe tuyere was blocked by slag and in the attempt to unblock the pipe, by pushing with iron rods, the tuyere was broken and the smelting operation abandoned.[56] It appears, therefore, that the function of a flux was understood but in many cases its use was found to be unnecessary.

To seek a traditional explanation of the smelting reaction in terms of Western science would prove a futile exercise, whether in terms of oxygen or the earlier concept of phlogiston which combustible materials were supposed to contain. Perhaps the only parallel would be the use of 'medicines' in the African furnace which could be compared with the unnecessary constituents of many alchemical recipes. Nor can we oversimplify the reaction as one between ironstone and charcoal, yielding iron and slag, providing there is no menstruating woman present. Menstruation, a negative factor in this reaction, could not be classed with such positive variables as temperature, pressure and mass which influence a chemical change. Such ethnocentric considerations exclude the possibility of a traditional interpretation in terms of a model. The concept of a model, perhaps too obvious to be noticed, provides a more plausible interpretation in the form of the reproductive woman, a model familiar to the 'primitive'. Here we have not only a mental image but one which is affirmed in the feminine symbolism of the furnace. In the absence of oral or written evidence for a theory, the model explained smelting in terms of reproduction, and identified the bloom with the new born child which, when later forged, was carried, baby fashion, on the back of a young girl — such was the custom in south-east Angola. We can conjecture that the ironstone corresponded to the foetus — was not the actual foetus added to the ironstone by the Tonga of Zambia and the Chewa of Malawi? In this model of the theory the charcoal at the base of the furnace might represent semen, as this is the most effective zone in reducing the ironstone to iron. Here, we are in grievous peril of confusing the model with the theory when its function is merely explanatory, and some aspects of the model may be completely irrelevant as in the example of the kinetic theory of gases where the colour of the billiard balls, representing gaseous molecules, is of no consequence. It is possible that the slag analogized faeces, as among the Ngoni of Malawi, but it might also simulate a miscarriage, due to sexual intercourse by the smelters who were thus committing adultery towards the furnace. The model appears as a personalized explanation of the smelting theory, a type of explanation more acceptable to traditional society, whereas in Western society the impersonal elements, because they are understood, are preferable vehicles of explanation where

[55] Kay and Wright, 'Aspects of the Ushi iron industry', 34.
[56] Prendergast, 'Research into the ferrous metallurgy of Rhodesian Iron Age societies', 258.

population mobility and instability render difficult a personalized theory, as well as a tendency to a more secular way of life.

Such speculation cannot be left without referring to Robin Horton's controversial and stimulating study of African traditional thought and Western science[57] in which he examines the similarities and the differences between tradtional ritual and scientific methodology. The differences are a warning that we cannot assume that traditional models are similar to those of Western science, but the similarities are sufficiently impressive to compel a comparative study of ritual and the philosophy of science. Some would, perhaps, regard the differences as of greater moment than the similarities, such as the continued faith in a ritual which has failed to achieve its object as compared with the scepticism accorded the repeated failure of a scientific experiment. No attempts appear to have been made experimentally to assess the effects of sexual taboos on the smelting reaction. Experimentation of a low order, without modern aids, could have shown that menstruation was not a factor in this reaction, but perhaps this would have destroyed part of the woof and warp of their society where, to cite a well-known line, '. . . in this web of belief every strand depends on every other strand, and a Zande cannot get out of its meshes because it is the only world he knows . . .'[58]

CONCLUSION

Much technical detail has been included in the first half of this paper for which no apology is required on the grounds that without such information a consideration and understanding of the significance of smelting ritual and the relevance of the philosophy of science is rendered difficult. Although iron-working in Africa covered a period of 1,500 years there has been no explanation of the smelting process in terms of African thought, nor any investigation of the possibility of such an explanation. Emphasis has been on the outward manifestations of African ritual especially with regard to sexual conduct and menstruation, without acknowledging their fundamental relevance to a process expressed as a personalized theory. Recorded interviews with aged informants who had witnessed iron smelting in their boyhood revealed no trace of causal action, nor did the smelters who were re-engaged in Zambia during the Second World War contribute an explanation. Perhaps they thought it completely unnecessary; the explanation was there for all to see in the moulded shapes of their furnaces.

[57] R. Horton, 'African traditional thought and Western science', *Africa* (1967), XXXVII, 50-71, 155-87.

[58] E. E. Evans-Pritchard, *Witchcraft, Oracles and Magic among the Azande* (Oxford, Clarendon Press, 1937), 194-5.

Finally, I cannot but contrast the social attitude to traditional iron-working with the public reaction, if any, to steel production today; for society in general, one was a sacrament, the other a means of livelihood. The traditionalist in me salutes that most discerning of philosophers, Mircea Eliade, writing of metallurgy and alchemy: 'Modern man is incapable of experiencing the sacred in his dealings with matter; at most he can achieve an aesthetic experience'.[59]

59 Eliade, *The Forge and the Crucible*, 143.