

Man, Metals and Magic: The Ancient History of Metallurgy

“4000 B.C. – 1400 B.C.”

Chapter II

The Chinese, who are credited with so many proverbs, are said to have the adage that “the *shortest step may be the beginning of the longest journey.*” It was the smallest conceivable advance that led primitive man to make a shallow cavity in the hearth of his fire to collect the metal he had learned to make. And it was a long eventful journey through the ages to the mid-twentieth century when furnaces were smelting 2000 tons of charge each twenty-four hours. A long eventful journey, it is also a fascinating one, full of incident. However, as our object is to outline a history of metallurgy, indicating where it has influenced and been influenced by contemporary events, we will follow a metal path so as to resist the temptation of turning aside and getting lost in the bush.

Metallurgical progress is outlined by the early manufacture of bronzes in the East; the vast, and unfortunate, impetus that the Roman occupation had upon mining; alchemy; the significance of iron making in the Middle Ages; the revival of industry in the 16th and 17th centuries; the metal production of America leading to a world supremacy; steel making and the machine age; and the development of metallurgical science.

The relationship between metallurgical development and our civilization is, of course, an inevitable one, but it is not always possible to differentiate between cause and effect. Clearly, in the very beginning, the discovery of copper led to the use of the metal for implements, and it was not a demand for copper that inspired its discovery. At the other extreme, it was the need for specific engineering materials that often led to the search and the invention of suitable alloys, which were not previously known, and only later applied.

In early times the discovery usually suggested a use, much as a child who finds an empty box will think of something to do with it. In more recent times the demand is prior. Once it is made, sooner or later it will be met – much as a child will demand a model railroad, and, if he makes himself a big enough nuisance, will probably get it. After one demand has been satisfied, more applications may well be found, modifications made, and so on. The child who found the empty box may kick it around the house, or make something of it; the one who has been given a model railroad may stamp on it, or alternatively demand a bigger one. So it is with practical discoveries. They may be used or abused, left idle or developed. Progress has been made by the alternate surging of invention and necessity; a game of scientific cat and utilitarian mouse.

At an early stage in this game, man made a shallow trough at the bottom of his campfire hearth, collected the metal there, and then beat it into shape. Gradually he developed this trough into a primitive furnace by digging a small hole and purposefully smelting metal in it by charging layers of charcoal and copper ore on a charcoal fire burning at the bottom. The hearth was made on the side of a hill. A stonewall was then built around the hearth to extend it upward. The wind, thus encouraged the fire, and the charge melted more rapidly. Any slag and unburnt charcoal were raked off and the metal cooled after all the ore was reduced. As soon as it had become solid, the copper cake was pulled out and broken up while still hot and brittle, and the pieces of copper were hammered to make suitable implements.

Analyses of such prehistoric copper show a complete absence of sulphur, indicating the use of oxidized ores or native metal. This is what one would expect, since the oxidized ores of copper occur at, or near, the surface and are the most readily available.

These advances led only to a more thorough exploitation of the natural resources of metal. Smelted copper was used in much the same way as native metal had been. Presumably, it was not long before the idea of casting was born. It became apparent that the lower surface of the metal cake assumed the shape of the hearth. By making the hole with suitable contours, it became possible to reduce the amount of work needed to chip and hammer the metal into shape.

Simple forms like axes and blades could be cast, but they were limited in value, as their upper surfaces were bound to be flat. Then castings were made in simple impressions cut into rock or pressed into clay. Before long, hollow molds were made of two pieces of stone held together so that a casting could be made that was shaped on all sides. Simultaneously, improvements were made in the smelting process. The hearth became bigger and relied more upon wind to stimulate the process that went on within it and certainly before 1500 B.C. bellows were introduced to produce a direct blast. The crude copper was refined through re-melting it in a deep, clay-lined hearth. The clinker and dirt that rose to the surface of the liquid metal were skimmed off, leaving a cleaner, purer material. Eventually, clay crucibles were made that dropped into the hearth. They could be lifted out so that metal might be poured into molds. Before the idea of a crucible was known, it is not known just how molten metal was transferred from hearth to mold. Presumably, a hot stone ladle or suitably cut channel was used.

In spite of this progress, stone implements were still widely used because copper is a soft metal and prehistoric man needed a harder, stronger metal. In some localities he was lucky enough to produce one owing to the nature of the ores he used. In these favored places the ores contained minerals in addition to those of copper, which were simultaneously reduced during the smelting process. Notable among these was cassiterite (tin oxide). Consequently, by accident rather than intention, an alloy of copper and tin was produced, rich in copper and something like the material we now know as bronze.

Its advantages were appreciated – it was harder and would more readily work harder than copper and, it was a better metal to cast, producing a sounder casting with a more faithful impression. Over time, it was realized that smelting together copper tin ores from different localities could make the alloy. For a long while, however, it was a mystery as to why the “copper” that was made in this way was so superior. It was only later that man learned to make bronze by melting metallic tin and copper together. As the proportion of tin in a bronze is quite critical (to give adequate properties for various purposes there should be between 1 and 10% of tin) the prehistoric production of bronze must have been a chancy business. While we can get some idea of the extent of bronze culture by the number of tools, ornaments and weapons that have been left behind on various sites, there is no indication of the vast number that must have been made, discarded and remelted; the same mystery surrounds many contemporary foundries. Tin ores, however, are not nearly so widely distributed as copper ores. Therefore, in some places the Copper Age was a prolonged one, and stone implements were used throughout most of it.

The Bronze Age

The bronze culture of Egypt was comparatively slow in developing, as the Egyptians' source of copper was the Sinai Peninsula, where tin did not occur. On the other hand, the use of bronze in Sumer began much earlier. In some areas the Bronze Age began so late as to be almost non-existent, for as a result of the knowledge brought by invaders or immigrants, the use of iron soon followed that of copper. This was so in Peru, where bronze was only just beginning to be made in the 16th century when the Spaniards arrived. In North America iron follows copper without any Bronze Age supervening.

The opening of the Bronze Age in the Ancient World not only represented the first production of a truly useful metal. Because of the comparative scarcity of sources of tin, it led to trading. The inhabitants of the second city of Hissarlik (the site of Troy) learned the art of bronze making about 2000 B.C. and discovered, too, that copper and tin could be obtained from Central Europe. Egypt, without tin and, therefore, without bronze, traded with Hissarlik and Crete. Further, about this time, bronze implements – probably from Hissarlik – reached Portugal and Spain. Soon afterward knowledge of the alloy spread along the coast of Western Europe to Great Britain.

About 1900 B.C. Hissarlik was burned down and its' commerce necessarily ended. Consequently, Cretan trade assumed greater importance. Much of this trade was with Egypt, which, however, about 1800 B.C. suffered a series of political misfortunes and eventually dropped out of the picture. As an outlet for their merchandise the Cretans were forced to find markets in Sicily, Spain and southern Italy – a process that ended with the exhaustion of their available tin. This was a fate that in turn was to come to many countries.

By this time, however, the Middle Europeans and the Spaniards had learned how to make bronze, and the cessation of supplies from the East acted as a stimulus to native industry. Because of Spanish manufacture, more bronze implements found their way into Britain, via the coast of France. But very soon the Spanish ores temporarily came to an end, for in those days only the most accessible deposits could be used, and hidden ore bodies were neither discovered nor exploited. Of necessity the Bronze Age began in Britain.

Another dissemination of bronze culture was brought about by the drought about 1600 B.C. that compelled the inhabitants of Turkestan, that country to the east of the Caspian Sea, to migrate to Mesopotamia and Egypt, and also to parts of Europe, India and possibly China. They had learned to make and use metals. Their domestication of the horse also gave them a superiority, which enabled them to form powerful settlements or dominate communities whose ways were more primitive.

The purpose of this brief account is to show how the advent of the Bronze Age increased the tempo of man's life. Before it, trading was almost unknown; exploration was inspired only by the fertility of the land, and by the animal instincts that prompted battle. Then, in a comparatively short space of time, the world was no longer so obviously divided into East and West. By about 1800 B.C. there were centers of bronze making dispersed over much of the known world.

The beginning of the Bronze Age in China is less clearly defined. Most surely it does not date so far back as the Sumerian bronze Age, for the earliest Chinese civilizations were in the valley of the Yellow River, where there were no obvious mineral deposits and the community was essentially an agricultural one.

The oldest Chinese bronze objects are supposed to date from about 2200 B.C. and about that time, metal mining began. If one accepts a traditional Chinese belief that the knowledge of bronze came to China from the West, this date is not an improbable one, for in Sumer bronze was known as early as 3000 B.C. The fact that there is little or no evidence of trading may be accounted for by the early exhaustion of raw materials in Sumer. The art of bronze making may have spread to China from this source, and the Chinese may well have been taught to find and use their mineral deposits. One must, presumably, believe either that this is possible or that Chinese metallurgy does not date back so far as 2200 B.C.

Although the Egyptians made a late start in the manufacture of bronze, their technique of casting soon became well advanced. Further, when they first dominated Syria soon after 1400 B.C. sources of tin were made available, and castings in bronze became much more common. No attempt will be made here to give even the barest outline of subsequent events in Syria, Egypt and Sumer (which by this time was part of the Babylonian Empire), for these are as involved as 20th century European history. Simply bear in mind that by 1400 B.C. bronze was made throughout most of the Ancient World, as well as in parts of Europe and China.

In all probability the Egyptians were responsible for the introduction of the *cire perdue*, or "lost wax," method of casting, which allowed metal articles to be made in exact replica of a model. Essentially, the process involved then, as it still does, making a solid model in wax to be covered with clay. Heating it hardens the clay and the wax is melted out, leaving a clay mold the exact negative of the model. Molten metal is then poured in, and allowed to solidify before the mold is broken away to allow the bronze casting to be removed. If a hollow casting was needed, then a core was fashioned roughly the same shape as the object to be made, and was coated with wax, which was molded exactly to shape. The clay mold was made over this, the core fastened to it by thin supports, and the wax melted out. Then metal was poured into the space that the wax occupied to produce a hollow replica. It is vital that the core should be firmly held, and the way in which the Egyptians did this is not known with any certainty. In later years iron struts were used, but this method is not very probable before about 1400 B.C. Bronze or copper struts would probably have been melted by the metal poured around them, and it is not very easy to imagine stone being used. However, this argument involves a bone of contention that will be gnawed later.

One of the earliest examples of "lost wax" casting is the statue of Pepi I and his son, dated about 2600 B.C. It is made of hollow copper or bronze, and the reproduction of detail illustrates how the Egyptians were masters of the art of casting at this early state.

The danger that metal might solidify before it had filled the mold was appreciated by the Egyptians who prevent this by allowing the metal to run by more than one entry, and also by heating the mold. Intricate castings, which could not be made in one piece, were fashioned in

sections that were joined together by a mortise joint or by a bronze pin, and these devices show a remarkable facility.

The man who could make metals was, as one would expect, a powerful and important figure. His power sometimes led to his being worshipped. Alternatively, he might have been hated. In some tribes, apparently to call a man "a smith" was an extreme form of abusive language. Not surprisingly the metal-makers' craft was associated with magic and wizardry. Perhaps that is how the name "blacksmith" came about. After all, if a man could turn a piece of hard, dull rock into soft, bright metal, he was certainly one to be held in respect, or fear. Consequently, the smith's hammer was a sign of power, and an oath taken over his anvil could never be broken.

Further, the smith was supposed to be able to foretell the future by looking at the molten slags in his furnace. Of course, the contemporary metallurgist should be able to foretell the *immediate* future by looking at his slags – he may even foretell the value of some industrial stocks – but the old smith's abilities went further than that. It is, perhaps, a pity that 20th century metallurgy has lost its supernatural associations. The most we can do in this sort of respect is to fool our admirers with thermo dynamic jiggery-pokery. And then we are all too often found out!

The uses to which copper and bronze articles were put during the period 3000 to 1400 B.C. should be considered cautiously. Today, we use aluminum for aircraft, but in 100 years time we may not. It is not very likely that aluminum planes will be left to slowly corrode away on garbage dumps. Consequently, the archeologist of 6000 A.D. may have no clue of what was once a valuable usage of aluminum. He may, however, discover an aluminum hot-water bottle discarded by English settlers and buried in an ancient rubbish dump, or some relics of an aluminum bottle opener. If he were hasty in drawing conclusions, he might say that the people of 2004 A.D. used aluminum mainly for hot water bottles and bottle openers.

It appears that the communities in the Ancient World, which practiced the art of metallurgy used bronze and copper for ornaments and weapons. This does preclude the possibility of more extensive uses. The greatest sources of bronze relics of this period lay in the tombs and temples of the rulers of the East, where ornaments and weapons were placed at the side of the dead to help them on their journey. Other remains have, of course, been found. But they are more rare and so we may get a distorted impression of the variety of purposes to which bronze was put. Yet, owing to limited resources and primitive methods, it is quite possible that bronze was not much more widely used until a later date, when it served for coins and a variety of household pots and pans, as well as for weapons.

Although until 1400 B.C. bronze and copper were used for the purposes that man's imagination and craftsmanship allowed, other metals were known too. They have been given no place in this account because bronze was by far the most important, both for its utility and because it opened up world trading, and the age is properly called a Bronze Age.

However, as already pointed out, gold and silver were known before the discovery of copper and, with the advent of melting and casting practices these metals were used more extensively for ornamental purposes.

In nature, silver often occurs with lead, whose sulphide mineral (galena) is bright and lustrous. Possibly then, mineral lead was noticed as early as silver. Evidence seems to indicate, however, that the metal was not made use of until a later period. Shapeless lumps of lead have been found at the site of Hissarlik, at a level dated about 3000 B.C. while an equally old lead relic in the form of a figure was found in the temple of Osiris at Abydos on the banks of the Nile. The metal, even though it may have been known in restricted localities, was certainly not appreciated for there is no evidence of a spread of "lead-culture."

One cannot be certain whether the metal was smelted or found native, for although lead does not normally occur in its metallic state, it is conceivable that it might have been produced by an accidental fire and discovered later. If, however, the lead objects of this period were smelted purposefully by man, it is difficult to explain why there are so few of them and why the value of lead was not exploited. Exploitation came much later. Although in 1400-1200 B.C., it was possibly used for coins of some sort, it was not until about 500 B.C. that its uses became at all extensive. Our arbitrarily chosen limit of 1400 B.C. up to which date events of metallurgical interests have been outlined, is of significance real, or false, depending upon which side of the fence one stands. One side of the fence thinks iron was first produced at this time. The other side of the

fence will dispute the choice of 1400 B.C. An accurate estimate seems to have defeated the archeologists, but for the purposes here, 1400 B.C. is as good as any.