

Israel and the Phœnicians. The latter traded throughout the world in the rich products of Palestine, and possessed greater skill in metallurgy than the Israelites, as is well shown in the Biblical account of the metal work of King Solomon's temple. Numerous Scriptural references show, however, that the Israelites had an intimate knowledge of the working of iron and steel. Iron was known in the days of Job (xxviii. 2). Moses mentions "Tubal-Cain, an instructor of every artificer in brass and iron" (Gen. iv. 22), and compares Egypt to "the iron furnace" (Deut. iv. 20). Og, king of Bashan, who lived about 1450 B.C., had a bedstead of iron (Deut. iii. 11). Joshua (ch. x., verse 20). It will be remembered, besieged Lachish, a city of the Amorites, which then became an important stronghold of the Israelites. It was finally deserted about 400 B.C. The mound has recently been explored by Petrie, who found in the remains of the Amorite city (probably, 1500 B.C.) large weapons of pure copper; above this dating 1250 to 800 B.C., appear bronze tools, which gradually become scarcer, until at the top of the mound there is little else than iron.

To our forefathers the Aryans in India iron was known at a very early date, and used for weapons and tools. Iron ore was abundant; and the lack of copper makes it probable that the iron age in India was not preceded by a bronze age. Indian iron and steel, even in very ancient times, were celebrated throughout the world; and the knowledge of metallurgy possessed must have been considerable. Evidence of this is afforded by the iron pillar at Delhi, which is 50 feet high and 16 inches in diameter, and appears to have been made of 50-lb. blooms welded together. It dates back to at least 912 years B.C. The primitive processes of iron and steel manufacture in India are described in detail by Dr. Percy; and in 1905 Dr. A. K. Coomaraswamy described the processes still surviving in Ceylon. The furnace is sheltered beneath the thatched roof of a shed open on all sides. The essential parts of the furnace are the well or furnace proper, a wall of sticks and mud to protect the bellows-blower from the heat of the fire, and the bellows behind the wall. The bellows consist of two hollowed logs of wood embedded in the ground, with a piece of deer-skin stretched over each, with a small hole near the centre to which a cord is attached. This is fastened above to a springy stick, the lower end of which is fixed in the ground. A small pipe conveys the blast into the furnace. The bellows-blower places a foot on each skin, and pressing his feet down in turn drives a continuous blast into the furnace; his foot acting as a valve, and the skin being pulled up by the tension of the cord. There is a bar for the blower to grip, and a strap to serve as a seat. The ore, limonite, is roasted previous to charging. The furnace is filled with layers of roasted ore and charcoal. When the bloom is ready it is taken out in long tongs made of green-wood sticks. Steel is sometimes made by a somewhat more delicate process. The wall and bellows are similar to those used for iron smelting, but the hearth is merely a semicircular depression filled with charcoal, into which the blast is conducted. Around this actual hearth is a low clay wall. The steel is made in clay tubes, each 8 inches long and 2 inches in diameter; the clay being 14 inches thick. Into it is placed a piece of iron and some chips of wood; the proportion being 12½ ozs. of iron to 5 ozs. of wood. The tube is then closed with a lid of clay, with small holes pierced for the escape of gas. The tubes are imbedded in the charcoal, and a fire started. Very soon the gases from the wood burn off; the blowing being stopped in the meantime. Then the blast is kept up continuously, while the tubes are turned about. When the steel is likely to be ready, a hole is

opened in the front part of the hearth so that the blast goes right through the furnace, and the tubes are lifted up one by one in long iron tongs and shaken to ascertain if the steel is liquid. The tubes are then allowed to cool, and subsequently broken open and the bar of steel removed.

The Indian methods of iron and steel manufacture were brought to European knowledge in the Middle Ages by gipsies, who appear to have come originally from India. In Hungary at the present day they carry on iron smelting and forging.

Another classic land for metallurgy is Armenia, the land of the Chalybes, whence the kings of Assyria drew tribute of iron. The Chalybes were regarded by the Greeks as the inventors of steel, and the name of the people was applied to steel.

Recent researches on early Chinese history have brought to light references to the use of iron and steel dating back to 2357 B.C. MARCO POLO, the Venetian, in the thirteenth century refers to the use of coal in China; but he gives no particulars of Chinese iron manufacture.

Japan appears to have been colonised from China about 1240 B.C. Japanese copper has been famed from the earliest times, and iron ore has long been mined. The mining operations until the introduction of Western methods were of a primitive character; but considerable depths appear to have been reached. Swedenborg, writing in 1734 (*"De Ferro,"* p. 194), states that the Japanese made their steel by forging iron into bars and burying these bars for eight or ten years in marshy ground; the unrusting portion then being steel. This process is described by several classic writers as being used elsewhere. It would be interesting to ascertain if there is any basis of truth in this description of the method of dealing with the mixture of wrought iron and steel produced by the imperfect smelting process used. The high quality of Japanese swords is far-famed; and the method of manufacture which enables them to be made still survives. The ore used was chiefly magnetic sand, which was obtained as far back as the year 1264. The ore was concentrated to about 60 per cent. of iron. The blast, which was worked by hand, was intermittent. The furnaces were rectangular, 10 feet long and from 4 to 6 feet high. The product is in part cast iron and in part a lump of malleable iron and steel. The antiquity of the Japanese iron industry has been proved by Professor Gowland, who has made a thorough study of Japanese metallurgy. In his investigations of Japanese dolmens, or stone burial chambers, dating from the second century B.C. to 700 A.D., he found iron swords, arrow-heads, spear-heads, and horse-furniture. In most countries the remains found in dolmens are of stone or bronze; but in Japan all belong to the iron age.

In Africa the metallurgical operations of the negro peoples who are regarded as the original inhabitants, present special interest. There was in Africa no bronze age, and the development of iron metallurgy was spontaneous. In Abyssinia the smith is looked upon with mingled dread and superstition. He is supposed to be able to communicate his magic power to others, and to turn himself into a hyena at will. The primitive African methods of iron and steel making in furnaces worked by natural draught have frequently been described. The most recent and most detailed account was that given by Mr. C. V. Bellamy in a paper read at the New York meeting of the Iron and Steel Institute in 1904, in which he described the process carried out in West Africa in the hinterland of the British colony of Lagos. The