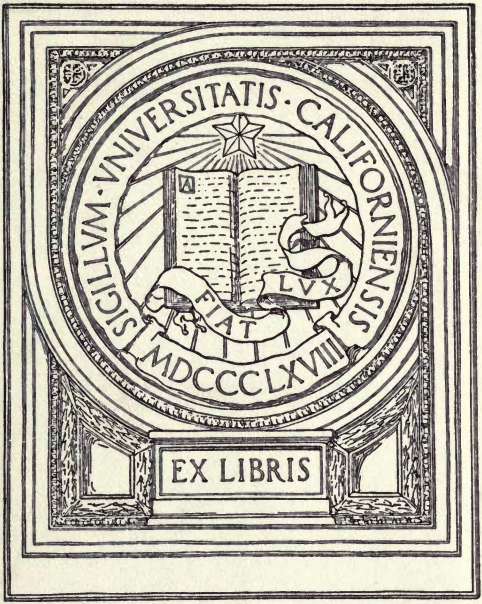
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THE

ANCIENT WORKERS

In Metal.

AND

ARTIFICERS IN METAL,

FROM REFERENCES IN THE OLD TESTAMENT,

AND

OTHER ANCIENT WRITINGS.

BY JAMES NAPIER, F.C.S. &c.,
Author of "Electro-Metallurgy," "Manuals of Dyeing," "Copper Smelting," etc.

"That which hath been is now; and that which is to be hath already been; and God requireth that which is past."—SOLOMON.

LONDON:
SIMPKIN, MARSHALL, AND CO.
OLIVER AND BOYD, EDINBURGH.
ARCHIBALD FERRIE, GLASGOW AND PARTICK.
MDCCCLVI.

1856

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PREFACE.

THE origin of metallurgical operations can only be subject of speculation, varying according to the position and imagination of the individual venturing the solution of such a problem. The wonderful results of the operations, and their importance to man, have caused many, both in ancient and modern times, to believe and assert that the art must have been communicated to man by the gods. Others, again, have ascribed the origin of the manufacturing of metals to accident—that certain minerals, by the force of fire, might be made to yield a metal, and by repeating the experiment on other minerals, other metals may have been found out, and ultimately all the different forms in which they lie concealed in the earth.

Various ancient historians speak of silver and other metals being melted out of the earth during the burning of woods upon the Alps and Pyrenees; and, even so late as 1762, a large mass of mixed metal, composed of copper, iron, tin, and silver, was melted out of the earth

during the conflagration of a wood which was accidentally set on fire.

Whatever may have been the origin of the art, certain it is that it originated at a very early period of man's history, has been carried with him to every part of the world, and down along the stream of time to the present day. And, like other arts, it has had, in different ages and different nations, its rise, prevalence, and decline, which, in the absence of clear historical evidence, makes an investigation of the progress of the art from early ages a difficult task. Yet, by the aid of the researches now being made amongst the ruins of the ancient world—by careful and extensive analyses of the various metallic products and induction—much may be collected towards a history of the progress of the metallurgical arts in the different ages of the world.

The numerous incidental allusions to works of art in the Scripture, had long excited my curiosity, suggesting the question as to the means which were then used to produce the works of art described. The occasional appearance of such works as "The Botany of the Bible," "The Geology of Scripture," etc., suggested the idea of the *Chemistry of the Bible*. To attempt a work of this sort, I thought it would be necessary to treat the whole subject inductively; and for this purpose, I collected all the names of articles given in Scripture, that are known

be the products of the chemical arts; but the list was extensive as to cause me to forego the experiment. t finding that the metals formed the greatest number any one class of objects, and had the greatest number references, these were adopted.

As to the method of inquiry which is here adopted, it pears to me to be one well suited to the practical man although he may not be what is termed a scholar. taking his own profession or trade, and thinking over requiremets for producing certain results or products, l then, if such products be named as having been in in ancient times, it may reasonably be concluded t similar operations would be required for their pro-ction, so far at least as general principles go; and by doing, Scripture history would become a very pleasing upation, and also of great benefit to every one who dertakes the study. It would not fail to give a much her appreciation of the acquirements of the ancients; l even many of our eminent scholars might gain nething by a little practical aid in determining the aning of certain technicalities in relation to arts.

When I began the present inquiry, it was with a very nble opinion of the ancients in respect to their know-ge of practical arts, but I have finished this short estigation with altered views. We have advanced in the metallic arts, but not in what may be termed

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to be the products of the chemical arts; but the list was so extensive as to cause me to forego the experiment. But finding that the metals formed the greatest number of any one class of objects, and had the greatest number of references, these were adopted.

As to the method of inquiry which is here adopted, it appears to me to be one well suited to the practical man —although he may not be what is termed a scholar. By taking his own profession or trade, and thinking over its requiremets for producing certain results or products, and then, if such products be named as having been in use in ancient times, it may reasonably be concluded that similar operations would be required for their production, so far at least as general principles go; and by so doing, Scripture history would become a very pleasing occupation, and also of great benefit to every one who undertakes the study. It would not fail to give a much higher appreciation of the acquirements of the ancients; and even many of our eminent scholars might gain something by a little practical aid in determining the meaning of certain technicalities in relation to arts.

When I began the present inquiry, it was with a very humble opinion of the ancients in respect to their knowledge of practical arts, but I have finished this short investigation with altered views. We have advanced far in the metallic arts, but not in what may be termed

the facts or main principles of art, but in the tools or means of production. We may make as much iron in one week as the ancients could do in one year. Noah took one hundred and twenty years to build his ark. A vessel of similar dimensions could now be produced in as many weeks, and much neater, still the ancients produced the article. We may do and see as much in our short span of threescore and ten years, as the antediluvians did in their eight or nine hundred years. In the matter of production, we live as long—in usefulness we may do as much. Whether we are improving our privileges, let each answer for himself.

PARTICK, *September*, 1856.

INTRODUCTION.

THE object in this inquiry is to trace out, from the references of ancient authors, especially those of the Old Testament, the probable state of the art of Metallurgy in their times. Particular attention will be paid to that branch of the art which embraces the extraction of the metal from the ore—as this cannot be done without a great amount of acute observation, as well as chemical skill, even although the parties possessing that knowledge and skill may not know them as a science in the same sense in which that term is applied at the present day.

The references made in the Old Testament, either by the historian or poet, to metallurgical processes, are very few, and some of them not very definite; consequently the general reader can form only an imperfect idea of the method by which these processes were conducted. Yet, although there existed no reference, the simple fact that metals were in common use, necessitates the inference, that they either must have been then obtained in a native state, and consequently requiring no process of extraction, or in a mineralised state, forming ores, and requiring great skill and difficult operations to extract

them. That the former was not the case, can easily be proved.

To understand more fully the difficulties to be met with in the processes of extraction, and to appreciate the skill required for overcoming such difficulties, it will be necessary to consider each metal separately, describing the methods now in use for obtaining the metal from the ore, including the various means adopted for overcoming natural difficulties; and thereby comparing any reference that may exist in Scripture or other works, we will see if such can apply to our present processes, or to methods known to have been in use, or to methods entirely lost.

In all arts which require the raw material, the nature of the country for producing it will, to a great extent, regulate the extent of knowledge the people inhabiting that country will possess. The inhabitants of a country, for example, that does not produce ores of metals, will not, as a natural consequence, know much practically of the art of extracting metals from ore, except some other natural circumstance interfere to procure a reversion of this rule. We have an example of this in our own country. Cornwall and Devonshire are the principal localities for producing ores of copper. These counties, consequently, produce the most skilled miners; but, from the absence of fuel or coal—an essential substance in smelting—the inhabitants are not copper smelters. Glamorganshire, which produces no copper ore, yet produces the most skilled smelters of copper ore, because of the extensive supply of fuel in that county, and its position to the ore-producing counties making it more convenient and

cheaper to convey the ore to the fuel than the fuel to the ore. Similar circumstances exist in Cuba and other localities, so far as regards copper ore. But in all cases where both ore and fuel are found together, as a general law, the locality producing them will also possess skilled miners and metallurgists, so far as regards smelting, or reducing the ore to metal; and the same circumstances will, to a certain extent, produce the same results in every age and every country. If metals are in demand, and the ores found in one locality and fuel in another, means will be adopted either to carry the ore to the fuel, as is done in our country, or the fuel to the ore, as is done in Chili and Australia; and if both ore and fuel are found together, they will be smelted on the spot, and the inhabitants of that locality will be skilled in the several arts of extracting and mining. If, then, our object was the locality of metallurgical operations, the inquiry would be into the physical character of ancient countries, which would lead to an inferential reply; but the present inquiry being more in reference to the operations than the locality where such operations have been conducted, we will not give any prominence to the locality, except where it may illustrate the operations themselves.

We know comparatively little of the metallic products of the land of Palestine. The different travellers who have visited that country, and who have recorded their observations, have either been incapable of giving the information, or their minds have been too much occupied by other matters, than to that of the mineralogical character of the locality; but from the few remarks that

they have made upon the geological features of the country, it is evident that the land of Palestine produced metallic ores. We know that fuel was abundant in the extensive forests of the country, and we have the testimony of Moses, who states, as an inducement to the children of Israel to leave Egypt and possess Canaan, that the hills produced copper and iron: "A land whose stones are iron, and out of whose hills thou mayest dig brass."* This statement we consider quite decisive, as it proves that Palestine produced ores of copper and iron; and the object for which this statement was made is strongly indicative of the high value such productions were held in those times, both by the Egyptians and Hebrews. No one can read over the detailed account of the structure of the ark, with its furniture, as given by Moses, but will see that there were amongst the Hebrews men well skilled in the art of fabricating metals, and by whom the idea of going to possess a country yielding metallic ores would be highly appreciated; nevertheless, we have little evidence of the Hebrews cultivating the art of Metallurgy to any great extent after settling in their own land. The skilled artificers who left Egypt appear to have died in the wilderness before obtaining an opportunity either for practising these arts, or teaching them to their children, who, along with their offspring, were for centuries afterwards so occupied in war—in taking possession of their own promised land, and providing for the more immediate wants of the community—that the arts, more allied to a people living in peace, were not only not practised, but

* Deut. viii. 9.

all knowledge of them was altogether forgotten and lost. And so effectually was this the case with the Hebrews, by their constant wars and vicissitudes, that in the days of Samuel we find the following graphic statement: "Now there was no smith found throughout all the land of Israel; for the Philistines said, Lest the Hebrews make them swords or spears; but all the Israelites went down to the Philistines to sharpen every man his share, and his coulter, and his axe, and his mattock; yet they had a file for the mattocks, and for the coulters, and for the forks, and for the axes, and to sharpen the goads."* And when the kingdom was established in Solomon's time, and when he was about to build the temple, he was obliged to arrange with Hiram of Tyre, for skilled artificers in metal, from amongst his subjects, to execute the work for that house, besides the workmen which David had taken captive from other nations and reserved for this great object — a sad illustration of the degrading effects of war upon a people.

The building of the temple of God at Jerusalem, of Solomon's house, and the peaceful reign and commercial policy of that monarch, no doubt gave a new impulse to the cultivation of the arts of civilised life amongst the Hebrews; and judging from their after history, it does not seem that these arts were ever so entirely lost by them, as it had been previous to Solomon. At the same time, so far as the metallurgical arts are concerned, although we have in their writings some of the most beautiful allusions to the operations

* 1 Samuel xiii. 19–21.

of working in metals, both by the poet and historian, indicating a minute knowledge of metallurgical processes, still, we have no evidence that the Jews ever excelled as a people in these arts, but were generally more dependent upon their neighbours than themselves for the products of the furnace.

The metals mentioned in Scripture, and also by the most ancient profane writers extant, are only six in number, namely, gold, silver, copper, lead, iron, and tin. Mercury or quicksilver was also known before the Christian era, and had been used in metallurgical processes; but no mention is made of that metal in Scripture, nor any allusion which we consider applies to it—consequently, it will not be considered.

It has been stated, however, that from the mysterious language used by the adepts in ancient times in reference to metals generally, but especially to mercury—which was looked upon as the mother by which all the metals were fructified, purified, and brought forth—that this metal may have been known to the Egyptians in the earliest ages, and also to the Hebrews, and referred to in such a way in the Scripture as to cause us to lose sight of its real nature; quoting such a passage as the following: "Only the gold, and the silver, the brass, the iron, the tin, and the lead, everything that may abide the fire, ye shall make it go through the fire, and it shall be clean; nevertheless it shall be purified with the water of separation: and all that abideth not the fire ye shall make go through the water."* This water, termed the "*water of separation*," has been referred to mercury.

* Numbers xxxi. 22, 23.

We quote the following from Sir John Petus' translation of the works of Lazerus Erckern, 1683:—

"And we are assured that in Moses' time they had the knowledge of all metals, as may be read in Numbers xxxi. 21, where Moses taught the soldiers how the spoils of their *heathen enemies* were to be purified. Commanding (as from God) that all their gold, silver, brass, copper, iron, tin, and lead, and everything that endureth the fire (in the furnace, according to the Syriac), should be purified by fire, and then to be accounted clean; yet it is also said in that text, that it shall be separated by the water of separation—by which water, certainly, is meant quicksilver—because this doth *purify, cleanse,* and *devour metals;* and so Dr Salmon calls it a *volatile juice* or *liquor;* for nothing but *fire,* or that *quicksilver, aquafortis,* can separate those metals. The water of purification of men was a distinct water from the water of *purification* and *separation* for metals, and the ingredients of the one are communicated to us, but the Holy Spirit thought fit to conceal the other from us."

Thus we see that this learned author acknowledges the want of information upon the nature of "*the water of separation,*" but he nevertheless is convinced that it was mercury, and that the Holy Spirit, in consistence with the general spirit of the age, kept it a secret. We think there is not the slightest foundation for this supposition. The water of purification was prepared by burning a red heifer entire, then collecting the ashes and mixing them with water, and allowing this to stand.* This ceremony was instituted several years previous to the passage re-

* Numbers xix.

ferred to in our quotation from Sir John Petus; and all that is stated in that passage is, that the passing of the metals through the fire did not render them ceremonially clean till they were afterwards washed by this water of purification.* Besides, mercury does not purify, neither was it used for separating copper, lead, iron, and tin, which metals are named with the silver and gold that were to be passed through the fire, and then washed in the water of separation.

* Numbers xxxi. 23.

GOLD AND SILVER.

THESE two metals, Gold and Silver, we intend to treat of together, for the following reasons:—

I. They are almost always associated together in nature.

II. In Scripture references they are generally both included.

III. The methods for their extraction and purification are similar; and

IV. They are associated together in mostly all manufacturing or commercial operations.

Both gold and silver are found in nature, in the metallic state, in great abundance, and, consequently, these metals are considered to have been the first to attract the attention of man, more especially gold, that metal being widely diffused through the earth in small quantities, but in the locality of the primary or plutonic rocks, the quantity is sometimes very great. The constant action of air and moisture upon the surface of these rocks cause their decomposition, and small portions are thus from time to time loosened and pulverised. The gold in the rock is not subject to this decomposition, but is loosened by the decay of the stone, and carried from the high to the low levels by rain, and is there subjected to currents of water, which carry away the light earthy

matters, and leave the gold in a more concentrated state, and, consequently, in course of time, large tracts of country become covered, it may be many feet deep, with this washed debris of the mountain, composed of sand and particles of gold. Hence, newly discovered countries, where the primitive rocks exist, are often gold-producing, the production being limited to the extent of valley so covered, as well as the depth of the debris. It often happens that, after the debris is exhausted, the original rock from which the valley had been filled is made productive by artificial grinding and washing, as is being done in Mexico, California, and Australia, the washing being conducted, when obtainable, by streams of water. The question, whether this artificial washing of the rock was practised in the early ages of man, we may have occasion to notice. But the natural condition in which gold is found in valleys has very early notice in history. Speaking of Eden, Moses says, "And a river went out of Eden to water the garden; and from thence it was parted, and became into four heads. The name of the first is Pison: that is it which compasseth the whole land of Havilah, where there is gold; and the gold of that land is good."* And again, Job, who, we think, wrote 1800 years before Christ, says, "As for the earth, it has dust of gold."†

From these natural circumstances, so distinctly stated in these passages, taken in connection with the natural properties and character of gold, viz., its being always found in the metallic state, its high specific gravity, its

* Genesis ii. 10–12. † Job xviii. 6.

colour, its polish, its malleability, etc., it is not surprising that it attracted the attention of the first inhabitants of the earth, and that they early began to use it for different purposes of life. In this first notice of gold, just quoted, there is a strong presumption that it had also been found in other localities than the one referred to, and that different qualities of the gold were known; hence the remark, "The gold of that land was good." This observation will appear more important and significant when we examine into the full application of it in reference to substances such as gold.

Gold is an element, and is not essentially good and bad, but by itself can only be of one quality; and, therefore, when different qualities are observed, it must depend upon certain admixtures. The only thing that can make gold bad is its having in it some other metal or metals; so that the observation referred to in the text warrants us in concluding, that, in that early age of the world, gold was an article of value, and that its value changed according to the state of its purity; but whether they had methods for purifying the gold from the inferior metals alloyed with it, so early as the days Moses refers to, is not stated; but that it was used for manufacturing articles, either for use or ornament, is highly probable, not only from the fact that it was familiarly known, but because iron and copper—two metals much more difficult to obtain and to work than gold—were used for some of the purposes of life by the great-grandson of Cain, who, we are told, was an "instructor of every artificer in brass and iron."* Indeed,

* Gen. iv. 22.

it is more than probable that the working in these two metals was the result of suggestions arising out of the practice of working in gold, which we have seen was found in the locality where these artificers lived; and if they knew how to make copper and iron from their ores, the gold could not possibly escape their notice.

We will now refer to the present methods for extracting the gold from the ores, or rather the earths, with which they are mixed; for, as already stated, gold is found in the metallic state in the primitive rocks or alluvial soil, in small thin leaves and threads, and little dendrical pieces attached to quartz, and sometimes in small loose particles in crevices of rocks, and also in pieces mixed with the alluvial soil, now popularly termed *nuggets*, but more generally in the form of small grains like sand, mixed with the debris of the primitive rocks. The metal is very seldom found pure, but generally contains silver, and often copper. The gold from different localities is characterised by the extent and kind of alloy which it contains, and even the same locality will produce little differences in quality; as for example, the quality of Californian gold has been given in 100 parts:*

	No. 1.	No. 2.	No. 3.
Gold, ...	90·01	86·57	90·70
Silver, ...	9·01	12·33	8·80
Copper, ...	·86	·29	...
Iron, ...	...	·54	·38
	99·88	99·73	99·88

The following is the analysis of Australian gold by A. D. Thomas, Australia:—

* Nos. 1 and 2 are by T. H. Henry, No. 3 by Rivot.

No. 1. Sample of metal coated with Iron Oxide.

Gold, ...	87·78	87·77
Silver, ...	6·07	6.54
Oxide Iron, . .	6·15	5·69
	100·00	100·00

Freed entirely from Iron by fusion, gave—

Gold, ...	93·53	93·06
Silver, ...	6·47	6·94
	100·00	100·00

Another specimen of Gold gave—

Gold, ...	96·42
Silver, ...	3·58
	100·00

When the gold is found in large pieces, as *nuggets*, it can be mostly all separated from the earthy particles by mechanical means, and then by fusion in a crucible —any small portion of earthy matter remaining, will separate and float upon the surface.

When the grains are small, and not easily separated from the earthy matrix by the hand, the whole is put into a crucible with a little borax, and fused, when the gold is obtained at the bottom as a small button or ingot; but when obtained in the form of dust mixed up with the soil, whether naturally or formed by grinding the rock, the whole is first subjected to washing, either by hand-basins, or by those vessels and instruments termed cradles, by which means the greater portion of the earthy matters are washed away; or the dust is put into a current of water, which is made to pass at a certain velocity over a large flat surface; or, what is very common, woollen cloths stretched out, the earth being carried along with the water current, and the gold falls and is retained by the cloth. This concentrated and washed gold dust

is collected into proper vessels, and a quantity of mercury or quicksilver is mixed with it, which imbibes or dissolves the gold or other metals, in the same manner as water dissolves sugar, and the earth is left upon the top of the mercury, and easily removed. In some fine gold dust there is sulphur and iron present, which greatly interferes with the perfect reaction of the mercury, the dust is therefore, in such cases, submitted to a roasting by fire, which drives off the sulphur and sets the gold entirely free to be taken up by the mercury. This mixture of mercury and gold, termed an amalgam, is subjected to a high heat in a retort, when the mercury distills over and is recovered in the same manner as steam is condensed into water, and the gold and silver and other metals present remain behind, and are separated by a process to be afterwards described.

Another method for extracting the pure gold from the gold dust, is by mixing with it a quantity of oxide of lead, *(litharge,)* and a little charcoal, with flux if necessary, and bringing the whole to fusion in a crucible. The oxide of lead is reduced by the charcoal to the metallic state, and combines with the gold and other metals present.

The lead, with the gold and other metals, is put upon a hollow plate or flat vessel made of bone ashes, called a cupell, and submitted to a good red heat. When in this state, a current of air is blown upon the fused metals, either by bellows or other instrument, which oxidises or scorifies the lead with all the other metals, except the gold and silver, which remain behind pure.

These are the methods now in practice for obtaining

the gold from the gold dust, yet the gold may be procured from the earthy matters, even although in fine dust, by merely putting it into a furnace or fire, and applying a strong heat; the gold will melt and collect at the bottom, and thus separate itself from the earthy matters; and if lime, soda, or such substance, be added with the dust, as a flux, these will combine with the earths, assist the fusion, and make the whole operation easy and simple; although in this process there is a much greater risk—nay, an almost certainty—of loss, and the metal being so valuable, this method is not now adopted. Still we are of opinion that this process was the method first adopted for extracting the gold and silver from their ores. All these processes refer equally to ores of silver, but silver being often found in a mineralised state, combined with other substances, as sulphur, chlorine, and oxygen, its ores are generally subjected to a roasting or calcining in a furnace before submitting it to the amalgamation process. A very old method, and still practised, for demineralising the silver, and causing it to combine with the mercury, is that termed the Patio process. The ore is finely ground and mixed up with common salt and sulphuret of copper, previously roasted and ground, and the whole made up into heaps, and tread out regularly by mules; mercury is added from time to time, and, in the course of from fourteen to sixteen days, the operation is complete—the mercury is separated from the mass, and contains the silver and gold, with other metals present, such as small quantities of copper. This amalgam is treated in the same manner as described for gold, by distillation.

Another method for mineralised silver ore is now adopted where opportunity presents itself. The ore is ground fine and mixed with common salt, and subjected to a dull red heat in a furnace; by this means the silver is converted into a chloride. The whole is then put into large casks or barrels with water, and scraps of iron and mercury. The iron combines with the chlorine, and the silver becomes reduced to the state of metal, and combines with the mercury forming an amalgam, which is carefully collected at the termination of the process, and distilled as already described. Although these processes are only applied to silver ore, yet any gold present is obtained along with the silver in the amalgam. In ores where the silver exists in the metallic state these processes are not necessary. When the lead process is applied, these last operations are also unnecessary—the raw ore being simply mixed with the litharge, charcoal, and flux, and fused, when the lead is obtained, containing all the silver and gold, which is afterwards cupelled, as described in the case of gold.

We have already mentioned that there are often copper and other metals along with both gold and silver. In such a case, if the metal is obtained by mere fusion, either with or without flux, these inferior metals remain alloyed with the gold and silver. If obtained by any of the amalgamation processes, the results are the same, the metals are got together; but if obtained by the lead process, and cupelled, all the inferior metals are oxidised and blown off, or absorbed in the cupell, with the lead; and the silver and gold are left pure.

When the gold and silver are thus alloyed, they are

purified by different methods, according as the circumstances admit, the principles of which may be thus stated: When gold or silver are thus subjected to a high heat, they remain, even during fusion, in a pure metallic state—that is, they do not become tarnished by combining with oxygen, but, on the contrary, if they were oxidised, a red heat will drive the oxygen away. If we take a piece of clean copper and make it red hot, it becomes black by combining with oxygen; if we take this coating of oxide off, and repeat the operation of heating, another coating of oxide is formed; and so on until the whole copper is oxidised. The same takes place with tin and other inferior metals. If, then, we take an alloy of copper, gold, and silver, and expose it to a fusing heat in a current of air, the copper will thus combine with oxygen, and if the oxide is removed from the surface, the oxidation will continue as long as there is copper present; leaving the gold and silver pure. If there be a large quantity of the alloy, the purification by this means will require a long time.

It has been long known that certain salts which contain large quantities of oxygen, when exposed to a high heat, give off this oxygen; one of these salts is *nitre* or *saltpetre*. This fact is therefore taken advantage of in purifying gold and silver. The alloy is fused in a vessel, such as a crucible, and, instead of exposing the fused alloy to the air, to oxidate the copper or other inferior metals, saltpetre is thrown upon the melted alloy, and this, by giving its oxygen to the inferior metals, effects their oxidation, thus purifying the gold and silver.

The alloys, or inferior metals, may also be dissolved

out from the gold and silver by means of certain acids—a process which we will have occasion to describe.

The impure alloy may also be mixed and fused with metallic lead, and then the whole subjected to cupellation, as already described. The purifying by nitre, acids, and cupelling, are all practised at the present day, according to circumstances.

Having thus described the operations for extracting and refining of the precious metals, we are now to inquire, according to our plan, what references are there in Scripture or other ancient writings which will enable us to infer that any of these operations were practised in these ancient times? or, if not any of these, what other? In this inquiry we may often be startled with references which indicate greater knowledge of metallurgical operations than we were prepared to admit; and whether we begin at the earliest ages and come up to the present, or reverse the inquiry, and go backwards, there is still the same evidence that the advancements made in working the precious metals in modern times over the ancients are not great in extent. Pliny describes the amalgamation process for extracting gold and silver from the earths nearly the same as practised at the present day; and, going back in the inquiry, the evidences are that all metallurgical operations were not only practised, but the operators and workers in metal were held in great esteem, and constituted an important item in a nation's prosperity; and that, during war, artificers in metal were preserved and taken captive, in order to enrich the conquering party, as illustrated in the following passage:—"And all the men of might, even seven thousand, and

craftsmen and smiths a thousand, even them the king of Babylon brought captive to Babylon."*

In ancient times, and up to within the last two centuries, an idea prevailed that gold was the only true metal, and that all other metals were different conditions of gold—that all metals could thus be transmuted or converted into gold—and that some substance existed, or could be made, which would have the power of converting every metal into gold. This idea obtained for all metallurgical operations a high position, and gave the study of the properties of the various metals, and their action and reaction with one another, and on other matters, a part in the studies of the learned. It need not, therefore, be wondered at, that the ancients became skilled in many metallurgical processes, and also knew many substances capable of acting upon the baser metals, and separating these from the noble metals. So early as the days of Job, familiar mention is made of refining:—"Surely there is a mine for silver and a place for gold, which men refine."†

In Scripture references we are more indebted to the poetical portion than the historical. The poet, to illustrate or enforce some great moral fact or principle, descends for an instant to some minute detail, in order to bring out the full force of the inference he intends to draw, and often but a single word gives a deeper and fuller illustration, and that same word is often of extensive meaning. In connection with our present inquiry, a beautiful illustration of this is found in the following passage:—"The words of the Lord are pure words, even

* 2 Kings xxiv. 16. † Job xxviii. 1.

as silver tried in a furnace of earth purified many times."* Here we observe David is not satisfied with saying that the word of the Lord is pure as silver tried and purified many times: he wishes to represent the most perfect state of purity, consequently he descends to a particular method, and says, tried in a *furnace of earth.* This distinct reference to an earthen furnace leads naturally to the conclusion that different methods were then known and practised, and that the earthen furnace was considered to be the best. Now, several methods have been described, by which we know gold and silver may be purified, independent of the process by mercury, for which we can find no reference in Scripture. These methods we will briefly repeat.

1st. Exposing the impure metal in fusion to a current of air. This method is not only tedious, but cannot be relied upon for perfectly purifying the gold, even though often repeated.

2d. Keeping the alloy in a melted state, and throwing upon it nitre. This is more quick and certain, but requires to be repeated to produce perfectly pure metal.

3d. Mixing the alloy with lead, and exposing the whole to fusion upon an earthen vessel—what is now found best, bone ashes or earth—and blowing upon this by bellows or other blast. This is by far the most perfect method, although it occasionally requires to be repeated to insure perfect purity.

We are, therefore, of opinion that the method is the process referred to by the Psalmist, and that all these three methods were then known and practised in

* Psalms xii. 6.

those times. Whether burned bones were used in making this earthen cupell, as is now used, is not indicated, but it is not essential to the operation, although found to be best. Although other earths may be used, it is not inconsistent with the common practice of those ancient times to use bone ashes, as we find that this substance was occasionally used in the arts, as indicated in the following passage:—"I will not turn away the punishment thereof, because he burned the bones of the king of Edom into lime."*

We are more fully borne out in supposing that the purification of gold and silver was performed by the cupelling operation in these early days, in the same way as we now do it, by other references in Scripture, some of which give glowing descriptions of the whole process, in the most beautiful poetical language, a few of which we will here quote, and in which the reader will not fail to see the correctness of the references:—

"Son of man, the house of Israel is to me become as dross: all they are brass, and tin, and iron, and lead, in the midst of the furnace; they are even the dross of silver. Therefore thus saith the Lord God, Because ye are all become dross, behold, therefore, I will gather you in the midst of Jerusalem. As they gather silver, and brass, and iron, and lead, and tin, into the midst of the furnace, to blow the fire upon it, to melt it; so will I gather you in mine anger and in my fury, and I will leave you there, and melt you. Yea, I will gather you, and *blow upon you in the fire* of my wrath, and ye shall be melted in the midst thereof. As silver is melted in

* Amos ii. 1.

the midst of the furnace, so shall ye be melted in the midst thereof."*

"Thy silver is become dross. . . . I will bring again my hand upon thee. I will purify thy dross, and take away all thine alloy."†

This, we think, is very descriptive of the process of cupelling, collecting the silver with its alloy, and melting it in the midst of a furnace, and, when melted, blowing upon it for the purpose of purifying, by burning off the dross.

Some commentators, however, when speaking of these passages, refer to the materials being collected and put into the furnace for the purpose of melting; the blowing having reference to the fire in order to produce an intense heat, such as in our blast or cupola furnaces. Now, we think such explanations are erroneous and inapplicable to the circumstances, entirely destroying the beauty of the figure; because—

1st. Such an alloy as named in the text melts at a very low heat—not more than that of a common kitchen fire—therefore the blowing of the fire to get intensity of heat is not necessary.

2nd. Were the materials named in the text put into the furnace, and the fire blown as is done in a blast or cupola furnace, the results which are said to follow could not follow, as the presence of the fuel with the metal would prevent scorification, no matter how intense the heat.

Now, compare the text with the cupelling process. The vessel containing the alloy is surrounded by the fire,

* Ezekiel xxii. 18–22. † Isaiah i. 22–25.

or placed in the midst of it, and the blowing is not applied to the fire, but to the fused metals—in the figure, to Israel—the object to be purified. And when this is done, nothing but the perfect metals, gold and silver, can resist this scorifying influence. And if anything were wanting to make more plain this view of the subject, that the cupelling process was then adopted and referred to in Scripture, we quote the following:—"They are all brass and iron; they are all corrupters. The bellows are burned, the lead is consumed of the fire; the founder melteth it in vain, for the wicked are not plucked away. Reprobate silver shall men call them."* This description is perfect. If we take silver having the impurities in it referred to in the text, namely, iron, copper, and tin, and mix it with lead, and place it in the fire upon a cupell, it soon melts; the lead will oxidise and form a thick coarse crust upon the surface, and thus consume away, but effecting no purifying influence. The alloy remains, if anything, worse than before.

The prophet says that the alloy was put into the fire with lead—the whole was melted. There is no lack of heat; but the lead was consumed—that which should have purified passes away, and the silver is not refined, because "the bellows were burned"—there existed nothing to blow upon it. Lead is the purifier, but only so in connection with a blast blowing upon the melted metals. We cannot pass over the aptness of the illustration in its application to affliction being sent upon a sinful people, to draw them from their wickedness, re-

* Jeremiah vi. 28–30.

presented by the heat and melting, and how ineffectual these will be in removing the sin or dross, if the Spirit do not accompany the operation and blow upon it.

There is another beautiful reference to these operations which still further proves the correctness of these views on the refining operations of gold and silver: "Who shall stand when he appeareth? for he is like a refiner's fire: and he shall sit as a refiner and purifier of silver, and he shall purify the sons of Levi, and cleanse them as gold and silver."* There is nothing in this referring to the process of refining further than the position of the refiner and the result of the operation. We will, however, endeavour to illustrate this reference: when the alloy is melted as before described, upon a cupell, and the air blown upon it, the surface of the melted metals has a deep orange red colour, with a kind of flickering wave constantly passing over the surface, caused by the combining of the oxygen with the impurity, and these being blown off; as the process proceeds, the heat is increased, because the nearer purity, the more heat is necessary to keep it in fusion, and, in a little, the colour of the fused metal becomes lighter—the impurities only forming reddish striea, which continues to pass over the surface. At this stage, the refiner watches the operation, either standing or sitting, with the greatest earnestness, until all the orange colour and shading disappears, and the metal has the appearance of a highly-polished mirror, reflecting every object around it; even the refiner, as he looks upon the mass of metal, may see himself as

* Mal. iii. 2, 3.

in a looking-glass, and thus he can form a very correct judgment respecting the purity of the metal. If he is satisfied, the fire is withdrawn and the metal removed from the furnace; but if not considered pure, more lead is added, and the process repeated. The appearance of a large mass of gold and silver upon a cupell, purified, is exceedingly beautiful.

The above reference may apply to a refiner at the side of the furnace casting into the melting pot the scorifying flux, as nitre, to burn away the dross, and watching its success. The metal in this case also assumes that mirror-like appearance described, but the flux and necessary shape of the vessel required for the process prevents it being so applicable to the illustration of the text. The cupelling operation being well known in the days of Amos, and this process being most suitable to the figure of the text, we are therefore inclined to the belief that the sacred poet refers to the cupelling operation.

In quoting a few more references upon the art of refining, it is not so much for the particular processes they adopted, as to prove that the operations were not only well known, but extensively and popularly understood, as the inferences, instructions, and warnings were for the people, and consequently written to be understood by the masses.

"When he hath tried me I shall come forth as gold."* "For thou, O Lord, hast proved us; thou hast tried us as silver is tried."† "Take away the dross from the silver, and there shall come forth a vessel for the finer."‡ "Behold, I have refined thee, but not as silver: I have

* Job xxiii. 9. † Psalm lxvi. 10. ‡ Prov. xxv. 4.

chosen thee in the furnace of affliction."* "And I will bring the third part through the fire, and will refine them as silver is refined, and will try them as gold is tried: they shall call on my name, and I shall hear them: I will say, It is my people: and they shall say, The Lord is my God."† From all these references we are of the opinion that the ancients, even in the time of David, and probably much earlier, practised the same methods for the purification of gold and silver that are done at the present day, notwithstanding all our scientific attainments and chemical skill.

We have repeatedly stated that all these operations have equal reference to gold and silver, so that when these metals are associated, they will be found together in a purified state at the termination of these processes.

We have also stated that gold is seldom if ever found in nature free of silver, the silver varying from 2 per cent. to 30 per cent.; and silver is seldom found free from gold, varying from 1 per cent. to 5 per cent. The separation of these two metals is an operation performed after the cupelling or purifying is completed. This operation is termed, in modern technical phrase, PARTING, and is performed in the following manner:—If the gold prevails in the alloy, it is not fit to be parted; more silver has therefore to be added. The proportions best for to undergo parting are 3 parts silver and 1 gold. The alloy is beat into thin plates, and then boiled in nitric or sulphuric acid, which acids dissolve the silver, but not the gold. The solution of silver is removed from the gold, which is well washed, and then melted in a crucible, and cast into

* Isa. xlviii. 10. † Zech. xiii. 9.

ingots or bars. The solution of silver has a quantity of common salt added to it, which precipitates the silver as a chloride. This is collected, and fused with carbonate of soda or potash, and the silver obtained as metal, pure. Or, there may be added to the solution of silver, sheets of copper, the silver being deposited upon these, and then collected, washed, and fused in a pot, and cast into ingots.

Whether these operations for parting small quantities of silver from gold, or gold from silver, were practised in ancient times, we can find no reference either in Scripture or any other writings to enable us to infer. Only two passages occur that refer to distinct and different operations applied to gold and silver. These are—"The fining-pot is for silver, and the furnace for gold;" and "As the fining-pot for silver, and the furnace for gold."* These are translated by some commentators thus—"As silver is tried by the fining-pot and gold by the furnace." Commentators also generally state that the *fining-pot* means crucible, or melting-pot. If this be the case, we know of no operation practised in modern times that the above passage will refer to—in other words, there is no operation in which a melting-pot or crucible is used that is peculiar to silver, nor any operation peculiar to gold that is performed by a furnace; for all such operations apply equally to both; and if any distinct operation existed in the times of Solomon, the process, so far as we are aware, is now lost. It may be, however, that the word fining-pot does not refer to a crucible, but to some operation practised for parting. If, for example, the

* Prov. xvii. 3; and xxvii. 21.

term *fining-pot* could refer to the vessel or pot in which the silver is dissolved from the gold in parting, as it may be called with propriety, then these passages have a meaning in our modern practice, and suit admirably the inference Solomon draws—a trying or testing of a man's character. However, this is but a supposition, and must be taken as such, even although plausible, as they may have had means of testing the quality of gold and silver in the days of Solomon that we have not. Except the above passages, there is no other evidence in Scripture of operations applied to gold and silver separately; but with regard to the operation of parting, we must remember that the ancient Egyptians were acquainted with both nitric and sulphuric acids, and also that nitric acid dissolved silver. The writings and markings upon ancient mummy cloth are now found to have been done by a solution of silver—the marking ink of our own day—and the solution of silver which they used is all but positively ascertained to have been the nitrate, which is strong presumptive evidence as to their knowledge of the action of acids upon silver.* This is a circumstantial proof in favour of their using such means for separating silver from gold, as this fact could hardly escape their notice, for in dissolving the silver the gold would be left. But that they were acquainted with all the requirements now known to us for obtaining perfectly pure gold and silver by such operations, would be asserting more than our references warrant; indeed, the constant references to certain qualities and kinds of gold in Scripture, is a kind of presumptive proof that

* See Appendix.

they were not in the habit of perfectly purifying or separating the gold from the silver, and the small quantities of silver remaining would give a distinctive character to the gold; and as different localities are known to produce gold with less or more silver, which, if their parting process was not perfect, the silver would not be perfectly separated, leaving certain distinct qualities of the gold of less or more value. Hence may be the permanent qualities spoken of as the gold of *Ophir*, gold of *Parvaim*, gold from the *north*, etc. etc. Beckmann states positively that the ancients did not know the means of separating gold and silver, thus, "The ancients used as a peculiar metal a mixture of gold and silver, because they were not acquainted with the art of separating them, and afterwards gave it the name of *electrum*."—(*History of Inventions*, vol. ii. 212, Bohn.) He thinks they considered this a distinct metal, but Pliny mentions electrum to have been made artificially by mixing four parts gold and one of silver, proving that in his day they did not consider it a distinct metal. It was also found in a native state.

We think, from what has been said in the references produced upon the metallurgical operations of gold and silver in Scripture, that the ancients were well versed in these arts, and that many of the most delicate operations, requiring considerable chemical skill, were also practised, and that the advancement made in these operations in modern times have not been so great as we are sometimes inclined to think. However, as we will have an opportunity of illustrating in another part of this volume, it appears that advancement in the arts has not been a

constant progress from the early days to the present; but processes and operations occasionally become lost, and are again discovered, and require a long time to regain former perfection. So that, in taking our stand at the present date, and looking over the vast gulf to the palmy days of Egypt or Israel, we lose sight altogether of what has passed in the interval; and except from the remains of art, and where the poet, to adorn his verse, has stooped to glean a fact from passing life, we have little knowledge of what the world has done in the practical operation of metallurgy.

It may assist our review, and give us a better appreciation of the extent of the art of working in gold and silver, and its general application and use in the common affairs of life, if we give a list of the articles used that were made of these metals.

In GOLD, we have, first, all sorts of jewels worn upon the person, as ear-rings, bracelets, finger-rings, nose-rings, and many others, worn by both men and women; then there were idols or gods, public and private, and images, hammered and molten; chains, curtain rings, hooks and eyes, girdles, breast-plates, tassels, bells, plates, spoons, basins, bowls, snuffers, dishes, covers, pipes, pots, lamps, tongs, hinges, candlesticks, censers, altars, mice, shields, tables, targets, calves, footstools, mercy-seat, snuff-dishes, flesh-hooks, crowns, emerods, sceptres, bedsteads.

In SILVER there were also jewels of various kinds—idols of various sorts—drinking-vessels of all kinds—sockets for hinges, hooks, chargers, bowls, trumpets, and other musical instruments, candlesticks, basins, images, arms, cups, chains, and many different sorts of vessels

not named; in all, such a goodly list as gives a very good idea of the general use to which these two metals were applied, altogether apart from the general use of these metals for gilding, or overlaying wood and other works of art and use, etc.

Both these metals were also used as money, and also by weight in exchange for other goods. From Scripture, we learn that silver was used for this purpose before gold, at least it is first mentioned—"And Abraham weighed to Ephron the silver which he had named in the audience of the sons of Heth, four hundred shekels of silver, current money with the merchants." *

Some commentators argue that because such a sum as this is named in silver, gold could not have been used as a coin, or for exchange. But this is a negative way of reasoning, and, if practised, would lead to many errors. The French, for example, name large sums of money in francs—a silver coin;—but it would be an error to conclude from this that the French had no gold coin; or if but one transaction were recorded in the reign of one of our kings, and that to be fifty shillings paid for any article, we would not think of reasoning from this that gold was not then used in exchange in that reign. The fact of silver being so distinctly named in the text quoted, is in itself favourable to the opinion that coins in other metals were in use. It is also said that, because the silver was weighed, it was not money coined as we have it, but pieces of silver, probably rings, stamped to indicate its quality. Whatever may have been the shape used, we think it refers to coins, not to mere weight.

* Gen. xxiii. 16.

A shekel is a name for a coin as well as for a weight. In olden times, as well as in some parts of the East at the present day, where regular coins are used, but from their not being milled in the edges, or other precautions taken to prevent them being scraped and lightened, the just and honourable merchant in transferring a number of coins weighed them; and Abraham, who was an upright man in all his transactions, and knowing well the character of the people he had to do with, weighed out the four hundred shekels of money. Four hundred shekels by weight, at four shillings and sixpence per ounce, is the same value as four hundred shekels in money coined.

The fact of using weights in transfers is of itself a proof of considerable advancement in commercial dealings, as a fixed standard of weight must previously be agreed upon. Probably the balances were first used in weighing metals or money as an article of exchange. This transaction suggests another necessity, namely, a standard of metal, whether coined or otherwise. It has been shown that the value of the precious metals is according to their purity, and therefore fifty shekels, by weight, of one quality, may not be worth more than the half of fifty of another quality; therefore some fixed standard of quality must be agreed to in commerce as a guide to all money transactions. The passage does not say that Abraham gave fifty shekels of refined silver, but fifty shekels of current money with the merchants. This is, no doubt, money of a fixed standard of value agreed to, or understood by the merchants, and this standard is founded upon, and rises and falls by, the quality of the metal; and this necessitates the means of purifying for

bringing them to the required standard, or ability in testing, to know the relative value.

The quantity of the precious metals possessed by men in ancient times, is another matter which has startled historians and commentators a good deal, from its vastness, and has caused many to question the accuracy of the statements, because we have nothing equal to it; a mode of criticism which is very erroneous, as it is setting up our own experience, or the experience of the present, as the proper test of the past, and this often without duly considering all the circumstances of the two periods.

For the last century or two, gold and silver were very scarce throughout the world, while the communities through which they have been diffused have become very extensive and widespread; so that great accumulations in one place have not been permitted, and are hardly possible in our commercial age. In ancient times this diffusive influence was much less, hence greater accumulations were made of the precious metals, both by individuals and nations. Besides, there have been periods in the world's history when gold and silver were got in very great abundance, compared with other periods; and the period from which we intend to take our data for comparing with the present age was probably one of the most favourable recorded in the history of the world, namely, the days of Solomon.

According to estimates made by Baron Humboldt, the whole produce of the precious metals from all the known countries in the world, from 1800 to 1848, was about £390,000,000. Since 1848, there has been the

new gold field of California, and following it, the still more prolific grounds of Australia, which, taking the whole from that period to have been equal to £30,000,000 as a yearly average from these localities alone, will give a sum of £210,000,000; this, added to the average usual produce of £8,000,000, multiplied by 7, is = £56,000,000, making in all, a sum for the last seven years, of £266,000,000—thus giving a gross, for the last fifty-five years, of £656,000,000.

We take the following from a late number of the *Edinburgh Philosophical Journal*, showing the amount of gold existing in the world at the present time:—

In 1848 the total amount of gold in use in the world was estimated by the best authorities at about £600,000,000, and the annual supply was believed to be between eight million and nine million sterling. From the recent extraordinary influx consequent on the openings of the gold fields of California and Australia, we may compute the amount now on hand at about £820,000,000. The data in this estimate are as follows:—

From a table in *Westgarth's Victoria*, it appears that these two regions have produced as follows:—

	California.	Australia.
1849,.....	£2,000,000	None.
1850,.....	9,000,000	None.
1851,.....	13,000,000	£1,000,000
1852,...	15,000,000	14,000,000
1853,..	20,000,000	20,000,000
	£59,000,000	£35,100,000

All other sources in five years,.. .....£40,000,000

To these add the product of £50,000,000 per annum from all quarters for two years, namely, 1854 and 1855 = £100,000,000.

Together, these stand in 1848,	£600,000,000
Last seven years,	234,000,000
	£834,000,000
From this deduct waste, estimated at £2,000,000 per annum for seven years,	14,000,000
Leaving nett product of	£820,000,000

This product is equivalent to about 205,000,000 troy ounces, or 8542 tons. Great as this amount seems, it could all be contained in a cubic block of gold of twenty-three feet in diameter.

It will be observed that these data seem to refer entirely to gold. According to M'Culloch, the whole produce of the precious metals, including gold and silver, previous to the discovery of the Californian and Australian gold fields, was about £9,000,000, so that the above data must include silver as well as gold.

In going back to biblical times, we have no such data as the statistics of mines throughout the whole world; but at the period we have referred to, we have an account of an extraordinary and systematic accumulation of the precious metals for a specific object, stretching over a period of forty years. From the day David was anointed king of Israel, he seemed to have been fully impressed with the belief of God's promise, that he was to be the instrument for establishing the Israelites as the first nation in the world, in connection with the worship of the true God; hence every victory he achieved was looked upon by him as the means which God was using for effecting this great end; and after defraying the necessary expense, remuneration, and rewards of his people and army, the remainder of

the spoils taken in war were accumulated for the great object of his life, as shown in such passages as the following: "And David took the shields of gold that were on the servants of Hadadezer, and brought them to Jerusalem. And from Betah, and from Berothai, cities of Hadadezer, king David took exceeding much brass. And Joram brought with him vessels of silver, and vessels of gold, and vessels of brass: which also king David did dedicate unto the Lord, with the silver and gold that he had dedicated of all nations which he subdued."* "And he took their king's crown from off his head, the weight whereof was a talent of gold, with the precious stones: and it was set on David's head. And he brought forth the spoil of the city in great abundance."† Even before David's reign this setting aside a part for God of all the spoils taken in war, was practised; and that much of what had been dedicated was in existence at the period referred to, is indicated by such passages as the following: "And all that Samuel the seer, and Saul the son of Kish, and Abner the son of Ner, and Joab the son of Zeruiah, had dedicated, and whosoever had dedicated anything, it was under the hand of Shelomith and of his brethren." But none, evidently, had the same fixed object in view as David, and which he made the prominent aim of his life. The law of Moses forbade kings accumulating gold and silver for private purposes: "Neither shall he greatly multiply to himself silver and gold."‡ This probably accounts for David's extraordinary personal liberality to the cause, and is another

* 2 Sam. viii. 7–11. † 2 Sam. xii. 30. ‡ Deut. xvii. 17.

proof of the sincerity with which he acted in all religious matters.

No sooner had David subdued the enemies of Israel and established his kingdom, than he began to develop the great object of his life—the erection of a temple, to establish religious worship in his kingdom, and make Jerusalem its great centre. He first calls an assembly of the priests, the nobles, and elders of the people representing the whole interests of the nation, along with Solomon, his successor, and divulges to them his great plan, the instructions he had received from on high, and what he wished them to do in helping on this great work, and announces his means for carrying it out: "Behold in my trouble I have prepared for the house of the Lord, a hundred thousand talents of gold, and a thousand thousand talents of silver, and of brass and iron without weight; for it is in abundance."* David, finding that his days were rapidly shortening, and his anxieties increasing for the peace and welfare of his young successor, and the fulfilment of his great work, calls another and probably more numerous meeting of the representatives of the people, and earnestly urges their interest in the cause, in the following language: "Now I have prepared with all my might for the house of my God, the gold for things to be made of gold, the silver for things to be made of silver, and the brass for things to be made of brass, and iron for things to be made of iron, and wood for things to be made of wood, onyx stones, and stones to be set, glittering stones of divers colours, and all manner of precious stones and

* 1 Chron. xxii. 14.

marble stones in abundance. Moreover, because I have set my affections to the house of my God, I have of mine own proper goods of gold and silver, which I have given to the house of my God, over and above all that I have prepared for the holy house, even three thousand talents of gold, of the gold of Ophir, and seven thousand talents of refined silver to overlay the walls of the house with."*

The response to this appeal and example was very satisfactory, and is no doubt the largest voluntary collection ever made for church building purposes: "Then the chief of the fathers and princes of the tribes of Israel, and the captains of thousands, and of hundreds, with the rulers of the king's work, offered willingly, and gave for the service of the house of God, of gold, five thousand talents, and ten thousand drams, and of silver ten thousand talents, and of brass eighteen thousand talents, and a hundred thousand talents of iron, besides precious stones,"† etc.

This contribution of David from his personal property is supposed by some to be included in the sum mentioned in our first extract; but this we think erroneous. Not only is this a separate sum, but it is stated by the donor to be applied for a specific purpose—the overlaying of the walls of the house—and its quality is referred to as being the best, "the gold of Ophir, and refined silver," and also evident from the fact that the others had already contributed from their share of the spoils to make up the large sum accumulated, as we find from the following statement: "Which Shelomith and his brethren were over all the treasures of the dedicated things, which

* 1 Chron. xxix. 2-4. † 1 Chron. xxix. 6, 7.

David the king, and the chief fathers, the captains over thousands, and the captains over hundreds, and the captains of the host had dedicated. Out of the spoils won in battle did they dedicate to maintain the house of the Lord."* So that the voluntary contributions made by David and the representatives of the people, were extra contributions. The gross sums calculated and reduced to our standard for the sake of comparison, will stand as follows: †—

Talent of gold worth £5475; the talent being 125 lbs. in weight, will make the value of the gold about 73s. per ounce. The talent of silver is given at £342 3s. 9d., or 4s. 4½d. per ounce. The gross of the value given will be—

Sum accumulated and in the public Treasury,	Gold, ...	£547,500,000
	Silver, ...	342,187,500
Contributed by David from his private resources,	Gold, ...	16,425,000
	Silver, ...	2,395,312
Contributed by the people,	Gold, ...	28,000,000
	Silver, ...	3,421,875
		£939,929,687

Being more than what has been raised in all the mines in the known world these last fifty-five years. When we consider the weight of all this metal, amounting to many thousand tons, it is not surprising that many are startled, and are rather inclined to suppose errors in the transcribing, than that so vast an accumulation could have been made by any one people.

The relative proportion of the metals seems to be a

* 1 Chron. xxvi. 26, 27.

† The value of the talent and other weights is taken from the Notes in Bagster's Comprehensive Bible.

fixed average in different ages—an average varying during long periods of time. The following are a few of these in ancient times, compared with the quantities given for the temple, etc. :—

Julius Cæsar exchanged gold for silver as			.....one to nine.
Menander gives in his day			.....one to ten.
Livy	"	"	.....one to ten.
Plato	"	"	.....one to twelve.
Herodotus	"	"	.....one to thirteen.
Weight named for Temple,			.....one to nine.

The relative quantities are no doubt very low, and are scarcely consistent with the expression that silver was so plentiful as to be little thought of in those days; but still this may be a reason why the voluntary gifts of the people were mostly in gold. They gave *willingly*, and also the best, hence the proportion of the metals in their gifts may not bear any relation to the general proportion. The relative value, according to the calculation taken, is one to sixteen.

But the quantity of the precious metals possessed by the Israelites at that period is no criterion of what existed in the whole world. The Phœnicians were then the masters of the sea, and had extensive commercial relations with most known countries, and had in their possession a vast number of miners working in different mines. Solomon was wise enough to perceive that, to maintain the greatness of Israel in peace, they must become a commercial people, and therefore made arrangements with Hiram, king of Tyre, for ships and men to navigate, and instruct his people in this art, and also fitted out a navy for himself, as stated thus : "And

Hiram sent him by the hands of his servants, ships, and servants that had knowledge of the sea."* "And king Solomon made a navy of ships in Ezion-geber, which is beside Eloth, on the shore of the Red Sea, in the land of Edom. And Hiram sent in the navy his servants, shipmen that had knowledge of the sea, with the servants of Solomon. And they came to Ophir, and fetched from thence gold, four hundred and twenty talents, and brought it to king Solomon."† And again, it is stated that "The weight of gold that came to Solomon in one year was six hundred and threescore and six talents of gold; beside that which chapmen and merchants brought. And all the kings of Arabia and governors of the country brought gold and silver to Solomon,"‡—the sum named being equal to £3,646,350; and if we take the proportion of silver, which is not taken into consideration, at the same as stated above, 1 to 9, there would be about £2,000,000, making a yearly supply of nearly £6,000,000, being a vast amount for an infant effort in maritime commerce. What the Tyrians would produce we have no means of knowing.

"It is traditionally related that when the Phœnicians visited Spain, they found the silver in such abundance, that they not only loaded their ships to the water's edge, but made their common utensils and even anchors of this metal. This statement harmonises with the representations given by the Spanish discoverers of Peru; and whether exaggerated or not, certain it is that the Phœnicians lost no time in taking possession of the country, and forming colonies in the present Adalusia.

* 2 Chron. viii. 18. † 1 Kings ix. 26, 28. ‡ 2 Chron. ix. 13, 14.

"When the Phœnicians first settled in the country, artificial mine works were unnecessary; the ore lay exposed to view, and a light incision was all that was requisite to procure it in abundance. The inhabitants were little acquainted with its importance until the demands of the commercial adventurers, and their avidity to possess it, first taught them its value. When the stock which the inhabitants had on hand, and for which they received various articles in exchange, was exhausted, the Phœnicians saw it necessary to open mines, and the fate of the Iberians afterwards became deplorable."*

The period which this tradition refers to is not stated; but if to the times of Solomon, it harmonises with the statement that Solomon's drinking vessels were all of gold—none were of silver, as silver was little thought of in those days, being plentiful as stones.

There are other facts referred to in Scripture which prove that the precious metals were much more abundant in ancient than modern times, in other parts of the world than that inhabited by Israel. The Queen of Sheba, along with other gifts, brought with her from her own kingdom to Solomon, gold: "And she gave the king one hundred and twenty talents of gold"†—equal to £657,000.

When Haman, the favourite of the Persian king, Ahasuerus, wished to prosecute his ambitious designs, and proposed his plan for destroying the Jews, thinking that it might be objected to from the effects it was likely to have upon the national exchequer, he makes the following offer: "If it please the king, let it be written

* Lawson's Scripture Gazetteer. † 2 Chron. xi. 9.

that they may be destroyed: and I will pay ten thousand talents of silver to the hands of those that have the charge of the business, to bring it into the king's treasuries."* If the talent referred to be the Babylonish talent, the sum will be about £2,119,000; but if reckoned by the Jewish talent, it will be upwards of £3,000,000, given by a private person for an object of ambition—a sum which would not affect his position as a man of wealth, or it would have frustrated his object. Gold is not named by Haman; but we are not to suppose that his whole wealth in precious metals was in silver, as we know from history that gold was very abundant amongst the Persians at that time. Herodotus relates that when Xerxes went into Greece, Pythius, the Lydian, had 2000 talents of silver, and 4,000,000 of gold darics, which is estimated at £5,500,000.

We take the following from Kitto's Cyclopædia of Biblical Literature, in reference to the temple of Belus, quoted from Herodotus:—"And there belongs to the temple in Babylon, another shrine lower down, where there stands a large golden image of the god, and near it is placed a large golden table, and the pedestal and throne are gold; and as the Chaldeans say, these things were made for eight hundred talents of gold, and out of the shrine is a golden altar. And there is another great altar where sheep offerings are sacrificed, for it is not permitted to sacrifice upon the golden altar except sucklings only; but upon the greater altar, the Chaldeans offer every year a thousand talents' worth of frankincense at the time when they celebrate the festival of the god. And there

* Esther iii. 9.

was at that time a statue of twelve cubits of solid gold; but I did not see it, but relate merely what was told to me by the Chaldeans. Darius Hystaspis wished to have this statue, but did not dare to take it; but Xerxes, his son, took it, and slew the priest who forbade him to move the statue. Thus is the sacred place adorned, and there is also in it many private offerings. These offerings made by individuals, consisting of statues, censers, cups, and sacred vessels of massy gold, constituted a property of immense value. On the top, Semiramis placed three golden statues of Jupiter, Juno, and Rhea. The first was forty feet high, and weighed one thousand talents. The statue of Rhea was of the same weight: the goddess was seated on a golden throne with lions at each knee, and two serpents of silver. The statue of Juno was erect like that of Jupiter, weighing eight hundred talents: she grasped a serpent by the head with her right hand, and held in her left a sceptre enriched with gems. A table of beaten gold was common to these three divinities, weighing five hundred talents. On the table were two goblets of thirty talents, and two censers of five hundred talents each, and three vases of prodigious magnitude. The total value of the precious articles and treasures contained in this proud achievement of idolatry has been computed to exceed one hundred and twenty millions sterling." The amount of the gold and silver taken by Cyrus when he conquered Asia, according to the account of Pliny, was £126,224,000 of our money.

We mention here what is related of Sardanapolis: "When his last hope was extinguished of saving the city, he fled into his palace, and ordering a vast pile to be

reared in the court, on which he accumulated all his treasure, amounting to a prodigious value, and close to which he placed his eunochs, his concubines, and lastly himself, he set fire to it, and perished amidst the splendid ruins. Athenians represent these treasures as worth a thousand myriads of talents of gold, and ten times as many talents of silver—this is fourteen hundred millions sterling."*

This account of Sardanapolis is, however, not considered reliable by historical critics. From these and many other statements in history, not included in the above references, we think we have conclusive evidence that gold and silver were much more plentiful in ancient, than they have been in more modern times, at least, they have been accumulated in greater quantities in certain localities, than now; and we think it is also presumptive proof that the ancients were well skilled in the mode of extracting these metals from the earths or their ores, and also in refining them from their impurities. The art of working in these and other metals —of fabricating objects of art and utility, will be considered in another part of this volume.

In the meantime, and before we leave for the present the consideration of gold and silver, we will offer a few observations upon that puzzle to commentators, and the object of ridicule to infidels and others, namely, the destruction of the golden calf made by Aaron in the wilderness, which in its manufacture and destruction is one of the most interesting circumstances in the history of the metallic arts mentioned in Scripture; and

* Encyclopædia Metropolitana. Vol. ix.

although contempt cast upon what we can neither explain nor accomplish is an easy method of getting over a difficulty, yet the statement cannot be thus got quit of. One generation may laugh at it, another explain away, but a third sees it in a different medium, and renews the inquiry. For the sake of our non-practical readers, we may explain, that from the high malleable property of gold, it cannot be ground, under the common idea of the word grinding. If any one takes a piece of gold, or even of copper, and tries to grind it to powder, say in an iron mortar, he would only flatten it; if done between stones, the effect would be according to the size of the pieces, but would not grind to powder. Under these difficulties, one class of commentators either deny the statement, or else maintain that Moses deceived the people, kept the gold, and substituted something else instead, which he made them believe was the gold. Others, again, unwilling to admit either of the above suppositions, or that they should be under the necessity of confessing ignorance of the method, have mentioned other means as explaining the difficulty, and there having been one operation suggested by which Moses might effect the grinding, it has been seized upon, and handed down as the probable, if not the veritable process adopted. Our first quotation is from Dr Kitto's History of Palestine:* "Commentators have been much perplexed to explain how Moses burned the golden image and reduced it to powder. Most of them offer only vain and improbable conjectures, but an able chemist has removed every difficulty on the subject, and has suggested this simple process as that which

* Vol. ii. p. 216.

Moses employed: Instead of tartaric acid, which we employ for a similar purpose, the Hebrew legislator used NATRON, which is very common in the East. The Scriptures, in informing us that Moses made the Israelites drink this powder, shows that he was perfectly acquainted with all the effect of this operation. He wished to aggravate the punishment for their disobedience, and for this purpose no means could have been more suitable; for gold rendered potable by the process I have spoken of is of a most detestable taste. To this from GOQUET it may be well to add, that the operation of the acids which act upon gold is much assisted by the metal being previously heated. In this we see the reason why Moses cast the golden image into the fire."

Dr Memes, in his Fine Art among the Jews, says,—"In all the processes of metallurgy, as well as in the different departments of metallic sculpture, the artizans were practically conversant. In one of these operations, difficult even to modern science, that of calcination, Moses shows himself proficient to a degree which formerly perplexed commentators, until the more recent experiments in chemistry showed that the golden calf might have readily been reduced to a calx by burning it with *natron*, of which abundance could be obtained in the desert."*

Calcination is to subject the metal or other substance to a red heat in contact with air, to oxidise it—one of the most simple and easily-performed processes in the art of metallurgy. To form a calx is to fuse the oxide of a metal, either alone or with a flux—also a

* Kitto's Journal of Sacred Literature. Vol. iii.

simple operation. Gold, subjected to calcination, wil not oxidise, and fusion with *natron* has no effec upon it.

On this subject Dr Eadie speaks in a still more positiv manner, making it more his own, thus: "To have drun of water so filled with particles of gold dust that the formed a kind of sediment in it, was no great hardship nor can we well understand how the ashes of the ca could be mingled with so much water as would suffice t be a powerful draught to the whole of the idolators but if we suppose that he who was learned in all th wisdom of the Egyptians, employed some chemical pre paration, such as was known to the ancient world, an dissolved the gold by means of *natron*, or other simila substance, the penalty was especially nauseous: th smell and taste of gold so dissolved are fearfully re volting." These last observations, as to the dissolvin of gold by natron—to the smell and taste given by th compound formed—are so stated that no one coul doubt but the Doctor is speaking of matters he practicall knows. Being afraid that natron, which is stated to b capable of dissolving gold, was something we did not know we turned up to what the Doctor says upon natron i his "Biblical Cyclopædia," the book quoted from; it i there said to be "*carbonate of soda.*" Now, if Moses use this substance to make the gold potable, it is a proces entirely lost. Nothing like it is known in the presen day, and if the Doctor could define the process, it woul be a most valuable discovery. The same chemica blunder seems to have been made by GOQUET, quote by Dr Kitto, as he refers to the matters used being acid

and that the heating in the fire was to assist its action upon the metal: natron is not an acid, but the opposite. Endeavouring to find the source of the opinions here given, and what eminent chemist was referred to in these extracts, we found, in "Thomson's History of Chemistry," that Stahll, who lived in the seventeenth century, discovered that if 1 part gold, 3 parts potash, and 3 parts sulphur are heated together, a compound is formed which is partially soluble in water. If this be the discovery referred to, which I think very probable, it has certainly been made the most of by Biblical critics. If we are allowed to mix up ten times the bulk of the calf of other matters in order to make a grindable or a potable compound, there are several other means of doing so than by soda and sulphur. But, unfortunately for these explanations, they do not agree with what Moses says he did. The account given in the Bible will not warrant us adding six times the weight of the calf along with it into the fire; and even although that had been done, it probably would not have taken up one-hundreth part of the calf, arising from practical difficulties in this process. In reviewing this matter, it may be as well first to consider what is said about the operation in the Bible, as it should be chiefly consulted: "And he took the calf which they had made, and burned it in the fire, and ground it to powder, and strewed it upon the water, and made the children of Israel drink of it."*

This last clause, "made the children of Israel drink of it," has added to the difficulty. As metallic gold is not soluble in water, the strewing of gold into the river

* Exodus xxxii. 20.

would not affect the taste of the water, consequently, the water was affected by the operation, then the gol must have been converted into a compound soluble i water. So far, then, this would necessitate some suc process as Stahll's, not only to have it capable of bein ground, but soluble; but we do not think that this claus *necessarily* means that the taste of the waters was affecte by the addition of the gold dust, but simply as an act c contempt to exhibit the utter worthlessness of such god which, I am informed by several scholars, is all tha is meant. Then a chemical compound need not b sought for to explain the difficulty. The mere act c grinding, either in a mortar, or between stones, could b easily effected by the addition of a very minute quantit of lead, or tin, to the gold, which renders it quite brittl and capable of being ground to powder; but we do no think that even this was done. In the recapitulator book a more particular account is given by Moses of th operations by which this grinding was effected, as fol lows :—"And I took your sin, the calf which you ha made, and burned it with fire, and stamped it, an ground it very small, even until it was as small as dust and I cast the dust thereof into the brook that descende out of the mount." *

In this account there is no indication of solubility but rather the opposite; because if it was soluble, an intended to make and keep the waters bitter for a time there was no necessity for grinding so fine as mentioned but apart from any supposition, let us follow this plai statement given by Moses himself of the operation—

* Deut. ix. 21.

1. It was put into the fire, no doubt, to cast it into bars or ingots of suitable size for the operations to follow.

2. "*And stamped it;*" that is, beat it out into thin laminæ or leaves. It is well known how thin gold can be beat out—much thinner than the finest paper now made; and Wilkinson, in his *Ancient Egypt*, says that the Egyptians were well skilled in the art of gold-beating, and consequently, so would Moses, as well as many of the Israelites in these times, as the following passage proves: "And they did beat the gold into thin plates, and cut it into wires (or threads), to work it in the blue, and in the purple, and in the scarlet, and in the fine linen and skilful work."*

3. "*And ground it very small, even until it was as dust.*" Gold-leaf placed between stones or in a mortar, and ground, can be thus reduced to fine powder, fine as dust—a little oil, honey, or any unctuous liquid moistening it, facilitates this operation. Extensive manufactories exist in England under a patent for performing these same operations at the present day, converting malleable metals and alloys into fine powder, known in commerce as metallic bronze; and so fine is this bronze, it resembles more the dust from the wings of a moth or butterfly, than metal. The lamilar structure of these dust particles will float in water for hours, and in a running stream for days; so that even Dr Eadie's difficulty of not knowing "how the ashes of the calf could be mingled with so much water as would suffice to be a painful draught to the whole of the idolaters," is thus easily got over—allowing that it was intended for the

* Exod. xxxix. 9.

people to drink the dust. Considering that these operations were performed in the wilderness by hand, it must have been very humiliating and painful for the idolaters to continue from day to day, probably from week to week, as it would require time, in the presence of the people, *pounding*, *stamping*, and *grinding* their god before which they had so recently danced, played, and bowed themselves, as the God who had brought them out of Egypt. Contempt could not be more complete.

The grinding of idols and altars that had been used in idolatrous worship was repeatedly practised afterwards. "And also concerning Maachah, the mother of Asa, the king, he removed her from being queen because she had made an idol in a grove; and Asa cut down her idol, and stamped it, and burned it at the brook Kidron."* "And when he had broken down the altars and the groves, and had beaten the graven images into powder, and cut down all the idols throughout all the land of Israel, he returned to Jerusalem."† "Moreover the altar that was at Bethel, and the high place which Jeroboam the son of Nebat, who made Israel to sin, had made, both that altar and the high place he brake down, and burned the high place, and stamped it small to powder, and burned the grove. And he brought out the grove from the house of the Lord, without Jerusalem, unto the brook Kidron, and burned it at the brook Kidron, and stamped it small to powder, and cast the powder thereof upon the graves of the children of the people."‡

* 2 Chron. xv. 16. † 2 Chron. xxxiv. 7. ‡ 2 Kings xxiii. 6, 15.

COPPER.

THE next metal, the metallurgy of which we are now to consider, is Copper. In our translation of the Scriptures, the word copper only occurs once, and that is when enumerating the various articles brought by the Jews from Babylon into their own country: "Also, twenty basons of gold, of a thousand drams, and two vessels of fine copper, precious as gold."* In reference to this notice, almost all commentators and biblical critics agree in maintaining that the vessels referred to were not made of copper, but of a rich alloy capable of taking on a bright polish, which we think highly probable, as copper was then in common use amongst the Babylonians, and would not be as precious as gold. Some commentators, however, without duly considering all the conditions required, suppose it probable that these vessels were made of *Corinthian copper*, or *Corinthian brass*, an alloy of peculiar richness, found in the ashes of some of the temples after the burning of Corinth, by the fusing of the various metals together; but Corinth not being burnt for several centuries after the return of the Jews from Babylon, these vessels could not be made of such an alloy. Others, with greater probability,

* Ezra viii. 27.

think they were composed of an alloy much esteemed amongst the Persians, composed of gold and other metals, which took on a high polish and was not subject to tarnish.

In reference to the copper of Scripture, it must be remembered that the translators of the Scriptures, not being acquainted with the technicalities of art, did not understand the distinctions which names bear in these arts; hence we have the word brass used synonymously with copper and bronze. Brass is a compound of copper and zinc; bronze is a compound of copper and tin—alloys of distinct character and composition, and of artificial production, there being no such thing as a *brass ore* or *bronze ore.* Consequently, when we read, "Brass is molten out of the stone,"* or, "Out of whose hills thou mayest dig brass,"† it is evident that it is not the alloy brass which is meant, but the metal or ore of copper. Besides, there is no evidence, either in Scripture or other writings, nor any remnants of ancient art, of the metal zinc having been known to the ancients. Consequently, there could be no brass; but copper was well known, and some of the mountains in Palestine produced that ore. When the word brass is used in Scripture in reference to ores, or being dug out the earth, it should be translated copper. In most other instances the word brass should be translated bronze, an alloy well known in the earliest times; and as copper is the principal metal in this alloy, it follows, that a reference to bronze necessitates a previous metallurgical operation for copper. The first

* Job xxviii. 2. † Deut. viii. 9.

mention we have of bronze is as follows: "Tubal-cain, an instructor of every artificer in brass and iron."* From this we observe that even in the antediluvian world the metallurgical arts were practised, a fact which harmonises well with the account we have of that magnificent structure, for such an early period, the Ark of Noah. Although it is not mentioned, we yet think there can be no doubt that the knowledge of metallurgy, and the art of working such metals as iron and copper, greatly facilitated Noah's operations, both in the preparation of materials, and in the construction of that monster vessel.

Copper is occasionally found in nature in a metallic state, so pure as to be used for manufacturing purposes, either for making articles of copper or alloys. There are examples of this in the mines of Lake Superior, in America, where large masses of metallic copper have been found, weighing several tons; it may therefore be considered possible that large quantities of copper were found in the earth in olden times; so that the ancients could possess this metal without the necessity of smelting. Here, however, we would mention the fact, that where a mass of copper weighing several tons is found embedded in the earth at any depth, it requires a greater amount of skill to get this into working operation than to smelt the ore. Such a mass cannot be broken up like a stone; it must be cut, and therefore requiring tools of particular hardness, and other mechanical appliances, to obtain which requires a greater and more refined knowledge of metallurgy than the smelting of copper from the ore.

* Gen. iv. 22.

But that the copper was obtained from the ore by smelting, is distinctly stated in the passage we have before quoted, "Copper is molten out of the stone."*

Copper is found in great abundance in nature in a mineralised state; that is, in combination with such substances as oxygen and sulphur, the separation from which is the primary object of smelting. These mineral combinations are termed ores. It is mentioned by some that the term copper comes from Cyprus, an island in the Mediterranean, which was originally peopled by the Phœnicians, probably from its being a mineral district. In Pliny and Strabo's time, this island was celebrated for minerals, amongst which are mentioned a variety of metallic ores. We think that the metal was known long before the Phœnicians were a people. The ores of copper are either very heavy, or they have beautiful colours, purple, blue, or green, and would on this account be calculated to draw very early attention. We mentioned in a preceding part, that gold and silver, when in union with oxygen, gave off that oxygen when heated to redness; but if oxide of copper be brought to a state of redness, the same effect is not produced, but on the contrary, the oxygen is more firmly fixed. So strong is the attraction of copper for oxygen, at this temperature, that if pure copper be heated to redness, it combines with oxygen, forming a black crust. If, when the oxide of copper is at a high heat, it be brought into contact with carbonaceous matter, such as charcoal, the carbon of the coal will combine with the oxygen in union with the copper, and form carbonic acid gas, and fly off, leav-

* Job xxviii. 2.

ing the copper in the metallic state. Hence, when an ore composed of copper and oxygen is mixed with coal, and brought to a bright red heat, the copper is reduced to the metallic state. Thus it is evident that when a piece of such ore is put into a fire, the copper will be reduced and will run down to the bottom of the fire or furnace; so that, so far as this kind of ore, namely, the oxide, is concerned, the process is so simple that even the rudest people living in the neighbourhood of such ore, could not fail to know the means of extracting the metal from it. Should the metal be combined with carbonic acid, forming the extensive class of ores termed carbonates, such as malachite, azure copper, etc., the same operations are applicable to them as described. The carbonic acid flies off at a dull red heat, and leaves the copper in a state of oxide; so that by the time the heat has risen sufficient to melt the copper, the ore is in the condition of oxide, and the copper will become reduced and melt as just stated. These two classes of ores are considered to have been the principal ores smelted until comparatively a late date; nevertheless, we do not see why we should limit the ancients in matters which we find so simple, and so closely allied to what they did know. When the copper is combined with sulphur, forming what is termed a sulphuret ore, it is first subjected for a considerable time to a dull red heat which drives off the sulphur, oxygen taking its place, converting the copper into an oxide. This operation of burning off the sulphur is done by first breaking up the ore into small pieces, and piling it up into a large heap, with air openings underneath; the ore

has mixed with it, small quantities of carbonaceous matter, such as coal, dried dung, turf, etc. The quantity of ore in the heap is generally sufficient for one month's smelting, and there are generally from twelve to fourteen heaps in connection with one work. When the heap is first made, it is covered over with clay or turf, a fire is kindled at one end of the heap, which communicates with the ore and carbonaceous matter, inducing a slow combustion of the mass, and this continues burning for a period of from ten to twelve months, during which the sulphur is not only driven off, but all the metals present are oxidised, and the earthy matters also brought to a condition more easily fused. This operation is termed calcining; and so scorching are the fumes given off, that no vegetation can exist for a long distance round these heaps. More recently this operation has been done in large reverberating furnaces constructed for the purpose; and a process of smelting, a little different from that already mentioned, is also done in reverberating furnaces, which we will refer to again. The method of calcining in the open air in heaps, is one that has been employed from very ancient times, and is still practised on different parts of the Continent, and in the island of Anglesea.

When a heap of ore is calcined, and the sulphur all pretty well burned off, the ore is transferred to a cupola furnace, as practised on the Continent, mixed up with the fuel and fused, when an impure copper is obtained; and if sulphur has remained in the ore, there will also be obtained a quantity of copper combined with it, termed a sulphuret. This last is subjected to another burning, to drive off more sulphur, and again fused; the impure

copper is also subjected to burning in an air furnace, and fused; the copper is then obtained, and afterwards purified by refining.

Where cupola furnaces are not used, the calcined ore is put into a reverberatory furnace, and fused. As the sulphur is seldom or never entirely taken out the ore by calcining, the fusion merely serves to separate the earthy matters with other impurities, and the copper and sulphur form a compound by themselves, which is afterwards subjected to fire and a current of air, to burn off the remaining sulphur, when the copper is obtained by fusion. If all the sulphur is driven away before fusion, then carbonaceous matters are mixed with the oxide of copper remaining, and copper is obtained as described for the oxide; but in the present day, carbonaceous matters are not used—the ores being impure, the copper is obtained by another reaction. In describing the present improved method for sulphurets in this country, we must remember that such ores always contain great quantities of earths, the copper present not being more than ten per cent. of the gross weight. The method of treating such ores is by breaking first into small pieces, and submitting them to a low red heat for several hours, in a large reverberatory furnace, which burns off a portion of the sulphur. The ore is then transferred to another reverberatory furnace, and fused, by which the earths combine and form scoria or slag, and are thus separated from the copper which combines with the remaining sulphur and iron, and from its gravity, sinks under the scoria. This is run from the furnace into water, and thus granulated. This

granulated mass is again calcined, and then fused as before, and so on, alternately roasting and fusing, until the iron and most of the sulphur are burned off—the copper and sulphur left are then existing in the condition known to chemists as a subsulphuret. It is then submitted to another roasting at a higher heat, when, by a beautiful chemical reaction, the copper is reduced to the state of a metal exceedingly pure. This beautiful, although tedious process, has been the result of long experience, and has become a necessary process for working ores, having in them different metals, which, by the fusing with carbonaceous matter, would be combined with and deteriorate the copper. These operations require about eight days' constant working, and a great deal of practical skill on the part of the workmen employed.

Whatever may be the process adopted for the extraction of the copper from the ore, there are practical difficulties experienced, arising out of the nature of the metal, as well as the character of the ore, and which must have existed in ancient times, as well as at the present day. These difficulties must be overcome before the metal is in a good condition for being manufactured into objects of art. Copper ores are very seldom pure, containing often small portions of other metals, which are capable of being reduced by carbon, either alone or in combination with copper, and being fusible at a temperature of melted copper, consequently becomes alloyed with the copper, and renders it impure. When this takes place, the copper is kept at a melting heat, exposed to the air, when the metals alloyed with

it, oxidise more rapidly than the copper, and are consequently burned or roasted off. Much copper, however, is lost by this method. Another process may also be adopted. If the alloyed copper be fused, and a quantity of pure oxide of copper added, this will tend to oxidise the impure metals, and purify the copper. The first of these processes is the one adopted at the present time, and the copper, burned or oxidised off with the impure metals, is recovered by other operations.

Again, pure copper when melted, as we have before stated, absorbs oxygen and other gases, as carbonic oxide, which renders it hard and brittle; and although it may be used for casting, it cannot be used for hammered or rolled work. Now, the means for overcoming this difficulty is by plunging into the melted copper a piece of green wood, and holding it there until a portion of metal taken out, and tested by hammering and breaking, shows it to be in a fit state for manufacturing purposes. This operation is termed refining, or toughening.

Whether any of these methods were practised by the ancients, there is no evidence, so far as Scripture references occur—there being no illustrations drawn from copper smelting, as we have from the purifying of gold and silver. Still, there is no doubt but they were subject to the same difficulties, arising from the nature of both the ore and copper, as smelters are subjected to now; and if they did not use the same methods, they must have used others equally efficient, otherwise the copper would not, in our opinion, stand working.

Again, in making alloys with copper that are to stand

rolling and hammering, the copper used must be of the best quality. Illustrations of this principle may be cited by referring to the well-known alloy termed *yellow metal*, which is so extensively used for sheathing, boiler pipes, and engine work. The copper for this alloy is made expressly for it, and termed *best select;* and if anything is wrong with the copper, either in refining or having an alloy in it, it will not suit. The same with bronze guns, and such articles of that alloy which have to stand great wear and fatigue. The copper must be of the best quality for success.

Many of the ancient copper alloys had to stand working by the hammer, and their bronze was such, either for toughness or hardness, that we cannot at the present day make anything like it, which is surely strong presumptive evidence that the copper, as well as the tin, they used for these alloys, must have been pure, and that they had means for effecting this object. This is further proved by some analyses made of ancient bronze, which will be found in another part of this work.

In searching for evidence of the modes of smelting copper, or any other metal in ancient times, there is very little data to be found upon which we can rely. Scripture is almost altogether silent, even in its figures, respecting the extraction of the common metals, except that expression already mentioned, "Copper is molten out of the stone." In ancient times such arts were kept secret, the few who wrought at them making a mystery of their operations. Such arts appear also to have been despised by ancient writers, consequently they did not notice them with any minuteness; hence, as

already stated, we are much more indebted to the figures and allegories of the poet, explained inductively, than by any direct description. In our opinion, the first method of smelting ores, was by heaping together wood and ore, and burning them in masses. In Macedonia, where lead mines were worked and the ore smelted, in the time of Philip, the father of Alexander, large heaps of slag are still found so far above the level of the rivers of the country, that the furnaces in which they were produced must have been worked either by bellows worked by human labour, or by the force of the winds.* Pliny mentions that king Numa, the immediate successor of Romulus, founded a fraternity of brass-founders (bronze-workers.) This statement, if correct, shows that copper, which is the principal constituent of brass, was plentiful. The same writer states that two distinct kinds of copper were exported from Cyprus, one called *coronarium*, which, when reduced into thin leaves and coloured with the gall of an ox, had a golden colour, and was employed for making coronets and tinsel ornaments for actors, from which circumstance it derived its appellation. Another variety, which was named *regulaire*, is not particularly described; like the former, it could stand hammering.

The copper of the next best quality came from Campania, where it was the custom to add eight parts of lead to every pound of copper.

It is also mentioned that in France it was usual to melt copper among red-hot stones, for the purpose of obtaining a steady heat, as a quick fire was found to blacken the metal and render it brittle. Pliny states

* Watson's Chemical Essays.

that the process was completed in one operation, and that the quality would be improved by more frequent melting; he also remarks that all kinds of brass melt best in cold weather.

Aristotle tells us that the Mosynæci, a people who inhabited a country not far from the Euxine Sea, were said to make their copper of a splendid white colour, not by the addition of tin, but by mixing and cementing it with an earth found in the country. These brief remarks give us no idea of how the smelting operations were conducted.

Pliny and other ancient writers are far from being correct in their descriptions of the manufacturing processes; even the translators of their works have added to the confusion, either through ignorance or on account of the poverty of the original language in technicalities, as we find brass in one place, copper in another, white copper in a third, all referred to indiscriminately—whether originally referring to pure copper, or whitened by the addition of tin, lead, or any other process. This being the case, we must use the inductive method, and more especially as a great part of our present inquiries extend to a much earlier date than the days of Pliny, etc.

It does not appear that pure copper alone was very extensively used by the ancients, either as ornaments or for use. This may be accounted for by the difficulty of toughening pure copper so as to fit it for the hammer; yet the fact that copper vessels have been discovered amongst ancient relics, made by hammering, shows that they were not ignorant of means of toughening. It has been mentioned that the toughening is effected by inserting poles

of green wood into the melted copper; but when copper contains small portions of oxygen, other matters may be used instead of wood, *e.g.*, if a small portion of lead or tin be added to the copper, this will effect the same purpose, although preventing the copper from being entirely pure, as any excess of tin or lead above that required to take out the oxygen, will remain in the copper. If the quantity is small, this would not affect the quality of the metal either for use as copper or for bronze, for which copper seems to have been principally used by the ancients; and that this mode of toughening was known to the ancients is more than probable from their great skill in manufacturing bronze. The best way to determine this question would be analyses of ancient copper, for, as a general rule, copper so toughened or deoxidised, will contain small portions of tin. The following are the only analyses we can find:—

Statues of copper horses erected in ancient times; date not known. Analysed by Klaproth—

Copper,	99·3
Tin,	·7
	100·0

Broken spear head. Analysed by J. A. Phillips. No date.

Copper,	99·71
Sulphur,	·28
	99·99

Coin A.D. 262. Analysed by J. A. Phillips—

Copper,	97·13
Tin,	·10
Silver,	1·76
Iron,	1·01
	100·00

Coin A.D. 267. Analysed by J. A. Phillips—

	No. 1.	No. 2.
Copper,	98·50	98·00
Tin,	·37	·51
Iron,	·46	·05
Silver,	·76	1·15
	100·09	99·71

With the exception of one, all these show tin in small quantities, and this would almost necessarily be the case if the copper was deoxidised by tin. Still the analyses are too few for drawing any positive inference, but these remarks will be strengthened when we come to treat of bronze.

Another reason for copper not being extensively used in a pure state for utensils, is its tarnishing quickly and producing a poisonous matter upon its surface, unfitting it for domestic purposes. Michaeli makes the observation, that Moses seems to have given a preference to copper vessels over earthern, and on these grounds endeavours to remove the common prejudice against their use for culinary purposes. But this is a dangerous conclusion, and no doubt formed from that confusion of terms referred to of calling bronze copper. We are inclined to think that Moses used no copper vessels for domestic purposes, but bronze—the use of which is less objectionable. Bronze not being so subject to tarnish, takes on a finer polish, and besides being much more easily melted and cast, would make it to be more extensively used than copper alone. These practical considerations, and the fact that almost all the antique castings and other articles in metal that are preserved from these ancient times being composed of bronze, prove,

in our opinion, that where the word brass occurs in Scripture, except where it refers to an ore, such as Job xxviii. 2 and Deut. viii. 9, it should be translated bronze.

The great skill of the Egyptians in working bronze at the time of the captivity is well known, both from history and the researches of modern travellers; and also from the vast quantity of relics found as memorials of those times, which are distributed through the various museums of Europe. The different articles of metal which were carried by the Israelites from Egypt, and the skill and ability displayed in working metals by the Hebrews, under the direction of Bazeleel and Aholiab, and the distinctive use to which the brass is said to have been applied, all point to an intimate knowledge of the metallic arts, which we will have occasion to notice more particularly in considering alloys of copper, and the character of the copper required for such alloys. And although there is no reference in Scripture to any particular method for smelting copper, or purifying it, still that knowledge was possessed; and they had means of effecting most, if not all, the operations required for the production of good copper from such ores as were found there. Before entering upon the skill which is displayed in the working in bronze, as indicated in the account given of such works as the Ark of Moses and Solomon's Temple, we will refer to a few corroborative notices respecting the extent of the knowledge of the art of working in copper and bronze in other countries, in olden times not yet referred to, and which will bear us out in some of our

previous observations respecting the purifying of copper. The following remarks upon ancient art among the Indians and Peruvians are exceedingly interesting:—

"Columbus, when at Cape Honduras, was visited by a trading canoe of Indians. Amongst the various articles of merchandise, were small hatchets made of copper, to hew wood, small bells, and plates, and crucibles for melting copper.

"When the Spaniards first entered the province of Turpan, they found the Indians in possession of abundance of copper axes.

"The ancient Peruvians used copper for precisely the same purpose with the Mexicans. They make their arms, knives, carpenters' tools, large pins, hammers for their forges, and their mattocks of copper, for which reason they seek it in preference to gold.

"The copper axes of the Peruvians differ very little in shape from ours; and it appears that these were the implements with which they performed most of their works.

"The knowledge of alloying copper was possessed by both the Mexicans and Peruvians, whereby they were enabled to make instruments of copper of sufficient hardness to answer the purposes for which steel is now deemed essential. Their works in stone and wood, whether in dressing the huge blocks of porphyry composing some of their structures, or in sculpturing their unique statues, which are found scattered over their ancient cities, were carried on entirely with such instruments.

"The metal used as an alloy for the copper was tin;

and the various Peruvian articles subjected to analyses are found to contain from 3 to 6 per cent. of that metal. A chisel analysed by Humboldt, contained—

Copper,	94
Tin,	6
	100

A copper knife from Peru, contained—

Copper,	96
Tin,	4
	100

Chisels, gravers, knives, and other implements found in Peru, all contained from 3 to 4 per cent. of tin.

"It is said that the Mexicans and Peruvians were wholly unacquainted with iron, and their carvings, etc., were all wrought with copper tools; they, however, contrived to harden them with an alloy of from 3 to 7 per cent. of tin. I have some of their implements in my possession, which answer a very good cutting purpose; it nevertheless seems incomprehensible how their extensive works in granite porphyry, and other obstinate material, could be carried on with such aids."* These extracts correspond well with the references to similar circumstances amongst the ancient Egyptians, found in Wilkinson and other writers. There is the same identifying of the word copper with the alloy of the same metal, having 3 or 4 per cent. of tin in it. These axes, hardened by a little tin, ceased to be copper axes, and this increases the difficulty of our inquiry, and which can only be cleared up by analyses of such named copper vessels or tools.

* Silliman's Journal, vol. ii. p. 51.

These extracts also show that the natives of other countries, as well as those referred to in Scripture, were well acquainted with the art of extracting metals from their ores, and of working in these metals, and even in some branches of it which many believe were the offspring of our own day. In illustration, we quote another paragraph from the same work: "The silver-plated discs, and also the embossed silver-plate, supposed by Dr Hildreth to have been a sword ornament, have been critically examined, and it is beyond doubt that the copper boses are absolutely plated, not simply overlaid with silver, and has been done by heat. It must therefore be admitted that they possessed the difficult art of plating, or had intercourse with a people who did."

We will reserve the consideration of the necessary knowledge of the art of working and fabricating articles in bronze, which must have been possessed by ancient nations, as indicated by the various articles of this alloy named in Hebrew writings, until we have treated of the metallurgy of tin, which was extensively used, and is a necessary ingredient of bronze; after which, with a description of the nature of, and difficulties in, the manufacture of bronze, the reader will be more able to value the skill required in the production of such alloys, necessarily involving much skill in the production of the metals from the ores, and their purification.

TIN.

TIN is very seldom found in the metallic state, and then only in very small quantities; but it is found abundant in some localities in a mineralised state, combined with oxygen and sulphur, termed respectively oxide of tin, and sulphuret of tin, which constitute the ores of that metal. The ores of tin are generally very heavy, and are found either in little pieces in the beds of rivers, mixed up with sand, or in veins of rocks in masses, mixed and combined with a stony matrix. The former kind is collected, and if not sufficiently concentrated, it is washed in a stream of water, which carries away the sand. The tin stone being left, the metal from this is consequently termed stream tin. The latter is stamped and ground to fine powder, and washed in the same manner, until the matrix is pretty well separated from the ore, which is carefully collected in heaps and conveyed to the smelting-house. If the ore be a sulphuret, which, however, is not common, it is subjected to a low red heat for some time, to dispel or burn off the sulphur, and convert the tin into an oxide. It is then subjected to a good red heat, mixed up with coal or other carbonaceous matter, which combines with the oxygen, and leaves the tin, which melts and runs down to the bottom

of the furnace, and is then let out as it accumulates. The ores that have no sulphur in them do not require any previous roasting, and are, consequently, treated in the same manner with carbonaceous matters. The tin is afterwards subjected to operations of refining somewhat similar to the copper, by melting and inserting into the mass poles of green wood. When other metals have been in the ore, and are reduced with the tin, such as copper, iron, etc., the pigs or blocks of impure metal are placed in a furnace at a heat sufficient to melt the tin, when the greater portion of that metal sweats out, as it is termed, and is thus obtained pretty pure; or sometimes the impure metal is kept in a melted state for some length of time, when the impurities, with a small portion of tin, take a different position from their gravity to the pure tin, and are by this means separated. These operations require much skill. Tin can be easily obtained from the ore, by mixing it in heaps with wood or charcoal, and setting the whole on fire, when the tin is easily reduced. The whole process is simple, and so allied to the other processes of metallurgy, that although there is no description left us of the methods followed for smelting, there is no difficulty connected with the process that would create a doubt as to the ancients having obtained it by the same means.

The ores of tin are not very extensively diffused through nature, and although found in great abundance in certain localities, these localities are few. There exist no evidence of tin ores having been found either in or near Egypt or Palestine. Where the inhabitants of such countries obtained their tin in the

early ages of the world, is uncertain. Some authors consider that it was obtained from the Indies; others, again, suppose that the Egyptians obtained it, as the Phœnicians did, from Spain and Cornwall; while not a few consider that the Egyptians obtained their tin through the Phœnicians, which gives a priority to that people. That they did obtain tin from the Phœnicians at certain periods of their history, is evident; but, in the early ages, Egypt had sources more direct for obtaining the great quantities they evidently required.

The existence of pure tin in a separate state, in very ancient times, is questioned by several able commentators and writers, from the word *Bedil*, which is generally translated tin, being equally applicable to a mixture of lead and tin, or a sort of refuse obtained from the refining of silver. "After an accurate investigation," says Beckman, "should everything said by the ancients of their supposed tin, be as applicable to a metallic mixture as to our tin, my assertion, that it is probable, but by no means certain, that the ancients were acquainted with our tin, will be fully justified." And again he says: "The Greek translators considered *Bedil* to be what they called *Cassiteros*, and as the moderns translated this by *Stannum*, these words have thus found their way into the Latin, German, and other versions of the Hebrew Scriptures, which therefore can contribute very little towards the history of this metal. The examination of the word *Cassiteros* would be of more importance; but before I proceed to it, I shall make some observations on what the ancients called *Stannum*. This at present is the general name of our tin, and from it seems to be formed

the *estain* of the French, the tin of the low German and English, and the ziun of the high German. It can, however, be fully proved that the stannum of the ancients was no peculiar metal, at any rate not our tin, but rather a mixture of other metals, which, like our brass, was made into various articles, and employed for different purposes, on which account a great trade was carried on with it.

"The oldest mention of tin is in the sacred Scriptures, Numbers xxxi. 22. Moses seems to name all the metals then known; and besides gold, silver, copper, iron, and lead, he mentions also *Bedil*, which all commentators and dictionaries make to be tin. It seems, however, probable, that in this passage, *Bedil* is our tin; but must it not appear astonishing that the Midianites in the time of Moses should have possessed this metal?"*

We do not feel the same astonishment at tin being named, even in this early age, along with copper and iron—metals more difficult to obtain; neither do we think Beckman need feel, consistently, surprised at the existence of this metal in these times, as he himself admits that bronze was known from the very earliest ages—and this being a combination of tin and copper, it could not have been made without tin; or if the word applied to a mixture of lead and tin, from which bronze was made, then such bronze would yield, by analysis, lead, copper, and tin, a circumstance which the analysis of ancient bronze does not verify, and which we will notice by and by.

As to the same word being applied to lead and tin,

* Beckman's History of Inventions; English Translation. Bohn.

when mixed with silver as well as pure tin, need not affect the probability of pure tin being known. Lead and tin are very seldom found together in the same ore; and where they are found mixed, it has been the result of accident or art. In our own workshops, it is quite common to call solder by the technical term *tin*, although known to have much lead in it. How obscure, then, would any description of art be to the general reader, where technicalities were used without explanation; and may not this be the source of much of the obscurity in Pliny, and others who treat of practical arts, who were not themselves skilled in them? As illustrative of such obscurity, take the following translation from Pliny:—

"Black lead has a double origin, for it is either produced in a vein of its own, without any other metal, or otherwise it is mingled with silver in the same mine, being mixed together in the same stone of ore, and they are only separated by melting and refining in a furnace. The first liquor that flows from the furnace is tin, (stannum,) and the second silver; that part which remains behind is galena, the third element of the vein, which, being again melted, after two parts of it are deducted, yields black lead."* The first part of this quotation, when speaking of the natural production of the ore, is clear, and easily understood; the second part, descriptive of the practical process, is as obscure as could well be conceived. We quote the following from an interesting paper by J. Phillips, F.R.S., on ancient mining in Britain:—

"Tin, the ore of which has been found at the surface

* Given by J. A. Phillips, in the Chemical Society's Memoirs.

in many situations, with auriferous sand and gravel, cannot have been long unknown to the gold-finders in the East and West. Some one of the many accidents which may and rather must have accompanied the melting of gold, would disclose the nature of the accompanying metal, whose brilliance, ductility, and very easy fusibility, would soon give it value. The melting of tin ore is, however, a step in advance of the fusing of native gold. The gold was fused in a crucible made of white clay, which only could stand the heat and chemical actions which that generated; but tin ore would, in this way of operation, prove entirely infusible. It must be exposed at once to heat and a free carbonaceous element. The easiest way of managing this is to try it on the open hearth. Perhaps some accidental fire in the half-buried bivouacs of the Damnonii may have yielded the precious secret. As to the fuel, we are told that pine wood was best for brass and iron; but the Egyptian papyrus was also used, and straw was the approved fuel for gold. In the metalliferous county of Cornwall peat is plentiful.

"As the bellows were used at least a thousand years before Pliny, we have here all the materials for a successful tin-smelter's hearth. If the smelting works were on waste land, and a little sunk in the ground, we recognise the old 'bole' or 'blooming' of Derbyshire, now only a traditional furnace, but anciently the only one for the lead and iron of that country. Pure tin once obtained, there must intervene a long series of trials and errors before its effect in combination with lead, brass, and silver, could be known—before the mode of

conquering the tendency to rust in the act of soldering, could be discovered. From all this, it follows that the smelting of tin might be, and probably was, performed by the inhabitants of the Cornish peninsula. This art they may have brought from the far East—Phœnicians may have taught it them. But all the accounts of the ancient tin trade represent the metal, and not the ore, as being carried away from the Cassiterides. Diodorus mentions the weight and cubical form of the tin in blocks carried from Ictias to Marseilles and Narboune, and Pliny says of the Gallecian tin that it was melted on the spot."

Dr Alexander, in his Ancient British Church, quotes the Rev. F. Thackeray's Research, as follows:—"The tin, lead, and skins of Britain, instead of being immediately shipped in Sicily, Cornwall, and other maratime districts, are said to have been taken to the Isle of Wight, thence transported to Vannes and other ports of Brittany, afterwards conveyed overland to Marseilles, and finally exported to all parts of the world which traded with the Greeks." Dr A. also states that Bochart deduces the word *Britannia* from the Hebrew word *Barab-anac*, "the land of tin."

Mr Richard Edmonds recently discovered some fragments of a bronze furnace in Cornwall, which he considers had been brought there by the Phœnicians, who gave such things in exchange for lead, tin, and hides. After some observations upon the locality where these fragments were found, and other correlative circumstances, he considers the manufacture of these fragments to date not less than two thousand years ago.

They were coloured by charcoal, and had a deep green coloured patna upon them. The analysis of these by Mr R. Hunt gave—

Copper,....	72
Tin,....	9
Iron,	4
Earthy matters,	3
Carbonic acid, etc.,	12
	100

Mr Edwards considers that the Jews had smelting houses near the shore, and that they purchased the ores from the natives, and smelted them for the Phœnicians. The town now where these relics were found is the oldest in the county, and has two names, each of which is significant of the suppositions he gives, namely, *Market Jew* and *Marazion*, or *Marghasion*, which means market mount, in Hebrew, called so, no doubt, by the Jews when they brought their tin. The former name was probably given by the natives, the miners, or sellers, hence the double name. The remnants of smelting pits are still called by tradition, *Jews' Houses.**

"The familiarity of the ancient Britons with tin, though this metal does not occur in a native state, may be readily accounted for from the ore being frequently found near the surface, and requiring only the use of charcoal, and a very moderate degree of heat, to reduce it to the state of a metal. We have no specific mention of any other source from whence the ancients derived the tin, which they compounded with the copper found so abundantly in several parts of Asia; with the single and somewhat vague exception made by Strabo, when he

* Edinburgh Phil. Mag., 1850.

calls a certain place in the county of the Drangi, in Asia, by the name of Cassiteron. That tin was known, however, from very early times, not only by the discovery of numerous early Egyptian and Assyrian bronze relics, but also by its being noted by Moses among the spoils of the Midianites, which were to be purified by fire; and by Ezekiel, among the metals of which Tarshish was the merchant of Tyre. . . . The allusions of Herodotus leave no room to doubt that his information was derived indirectly from others. The Phœnicians long concealed the situation of the Cassiterides from all other nations; and even Pliny treats as a fable the report of certain islands existing in the Atlantic, from whence white lead or tin was brought. It need not, therefore, suprise us to learn so little of these islands from ancient writers, even though we adopt the opinion that they continued for many centuries to be the chief source of one of the most useful metals. Antimony is found in the Kurdish mountains, and pure copper ore abounds there as well as in the desert of Mount Sinai; but no tin is found throughout any part of Assyria. It is a metal of rare occurrence, though found in apparently inexhaustible quantities in a very few localities. The only districts, according to Berzilius, where it is obtained in Asia, are the islands of Banca, only discovered in 1710; and the peninsula of Malacca, where Wilkinson conceives it possible that tin may have been wrought by the Egyptians. The mines of Malacca are very productive, and may have been the source from whence Tyre derived 'the multitude of riches;' but we have no evidence in support of such conjectures. Cornwall still yields a larger quantity of

the ore than any other locality in the old or new world where it has yet been discovered, and many thousands of tons have been exported by the modern traders to India, and China, and to America. Taking all these circumstances into consideration, it seems in no degree improbable that long before Solomon sent to Tyre for a 'worker filled with wisdom and understanding, and cunning to work all works in brass,' or employed the fleets of Hiram, king of Tyre, to bring him precious metals and costly stones for the Temple at Jerusalem, the Phœnician ships had passed beyond the pillars of Hercules, and were familiar with the inexhaustible stores of these remote islands of the sea, which first dawn on the history as the source of this most ancient alloy. Strabo's description of the natives of the Cassiterides is not to be greatly relied upon. According to him, they were a nomade, pastoral race, of peaceful and industrious habits; but he refers especially to their mines of tin and lead, the produce of which they exchanged with the foreign traders, along with furs and skins, for earthenware, salt, and copper vessels and implements."*

It is, therefore, probable that, in ancient times, the tin ore was smelted at or near the mines, which accounts for the absence of all allusions to the methods of smelting of tin in Scripture, or other histories. That the Phœnicians were the principal importers of this metal, along with many other metals, during the height of her prosperity, and that they supplied other nations, is borne out by the language of the prophet in reference to Tyre: "Tarshish was thy merchant by

* Wilson's Archeology and Pre-Historic Annals of Scotland.

reason of the multitude of all kinds of riches: with silver, iron, tin, and lead they traded in thy fairs,"* (markets.)

The first mention of tin in the Scriptures is after the Israelites had fought against the Midianites. It constituted a part of the spoils taken from that people, and the reference is to the method by which such metals were to be made ceremonially pure, thus, "Only the gold, and the silver, the brass, the iron, the tin, and the lead, everything that may abide the fire, ye shall make it go through the fire."†

This ceremony of passing the metals through the fire, has been supposed by some to mean making them red hot. Such an idea is absurd. Many of the metallic articles taken in this and other wars, were no doubt manufactured, and the attempt to make them red hot would destroy them. Tin, for instance, melts at a temperature of 420° Fah., about twice the heat of boiling water, and only half of the temperature of redness, and lead melts at 620° Fah.; so that, if the passing through the fire meant making them red hot, it would melt both the tin and the lead. The passing through the fire, in my opinion, means a mere heating to destroy organic matter, which would be effected by passing them *suddenly* through a fire, or the mere flame of the fire, but not remaining to give them anything like a red heat. I have seen a somewhat similar practice before *bath-brick*, or such polishing materials, had reached remote dwellings —the blades and prongs of knives and forks before being used were plunged into the red glowing embers, and then

* Ezek. xxviii. 12. † Num. xxxi. 22, 23.

wiped clean and made ready for use. A similar practice is referred to by the prophet: "Then set it empty upon the coals thereof, that the brass of it may be hot, and may burn, and that the filthiness of it may be molten in it, that the scum of it may be consumed."*

The relative value of tin, with the other ordinary metals, is nowhere stated; but that it was classed with the ordinary, or inferior metals, is apparent from such passages as the following, where it is ranked amongst others, as an impurity in silver: "The house of Israel is to me become dross: all they are brass, and tin, and iron, and lead, in the midst of the furnace; they are even the dross of silver."† Isaiah also refers to tin, but it is evident that the word translated tin, does not refer to that metal, but to the alloy: "And I will turn my hand upon thee, and purely purge away thy dross, and take away all thy tin"‡ (alloy.)

These are the only references in Scripture where tin is directly named, but they give no indication that tin was used alone in the manufacture of vessels or ornaments; although the ease with which it melts and can be cast, the whiteness of its colour, and not being subject to tarnish, inclines us to the belief that it was used alone for various purposes.

Neither is there reference in Scripture to the use of tin for overlaying or plating other metals, like the tin plate of our day, and the coating of copper utensils for protection from their poisonous qualities. Both uses are referred to by Pliny as being common in ancient times, and to have been done in a very perfect man-

* Ezek. xxiv. 11. † Ezek. xxii. 18. ‡ Isaiah i. 25.

ner; and he says the articles so tinned could scarcely be distinguished from silver, and adds, that the tinning did not increase the weight of the vessels, the metal was applied so thin.

Beckman says: "That vessels were made of cast tin at an early period, is highly probable, although I do not remember to have seen any of them in collections. I am acquainted only with two instances of their being found—both of which occurred in England. In the beginning of last century, some pieces of tin were discovered in Yorkshire, together with other Roman antiquities; and in 1756, some tin vessels of Roman workmanship, with Roman inscriptions, were dug up in Cornwall."*

From the ease with which tinned iron is destroyed, by exposure to a damp atmosphere, it could hardly be expected to be found now, although the process had been in general use in ancient times.

Other applications of tin, which give evidence of great advancement in the arts, are known to have existed in the oldest times. According to recent discoveries, the oxide of tin was used, both by the ancient Egyptians and Assyrians, for enamelling and glazing earthenware, an application which was considered quite a modern invention.

* Beckman, vol. ii. Bohn's Edition.

BRONZE.

THE great and positive consumption of tin in ancient times was in the manufacture of bronze; and the quantity used for this purpose must have been very great, as this alloy seems to have been in general use, both for objects of utility and art. In Scripture the following are named as being made in bronze:—Tatches, lavers or baths, sockets, pins, grates in network, curtain rings, altars, fetters, helmets, greaves, pillars, bases for pillars, plates, shovels, pots, cymbals, shields, harpoons, gates, mirrors, censers or ashpans, bars, wheels, scaffolds, flesh-hooks, fire-pans, basins, images, serpents, oxen, bulls, chapiters, etc. This general use, referred to in Scripture, is more than verified by the researches of Wilkinson, Layard, and others, who have found bronze articles in abundance that are not named in Scripture; and of a quality indicating a much more perfect knowledge of manufacturing that alloy than we possess at the present day—there being found carpenters' and masons' tools—as saws, chisels, axes, hammers, etc.; and knives, daggers, swords, and other articles, requiring both fine edge and elasticity—articles which, were we to make, would be useless for the purposes for which the ancients applied them. Wilkinson says, "No one who has tried to

perforate or cut a block of Egyptian granite will scruple to acknowledge that our best steel tools are turned in a very short time, and require to be retempered: and the labour experienced by the French engineers who removed the obelisk of Luxor from Thebes, in cutting a space less than two feet deep along the face of its partially decomposed pedestal, suffices to show that, even with our excellent modern implements, we find considerable difficulty in doing what, to the Egyptians, would have been one of the least arduous tasks."*

And that bronze chisels were used for cutting granite, Wilkinson believes, as he found one at Thebes, of which he says, "Its point is instantly turned by striking it against the very stone it was used to cut; and yet, when found, the summit was turned over by the blows it had received from the mallet, while the point was intact, as if it had recently left the hands of the smith who made it."

"Another remarkable feature," adds the same author, "in their bronze, is the resistance it offers to the effects of the atmosphere—some continuing smooth and bright though buried for ages, and since exposed to the damp European climate. They had also the secret of covering the surface with a rich patina of dark or light green, or other colour, by applying acids to it."†

These few extracts, which we will presently illustrate more fully, respecting bronze and the skill of the ancient Egyptians in working metals at the time the children of Israel were captives in Egypt, many of whom, we are of opinion, were the working-men in their foundries and

* Wilkinson's Egypt, vol. ii., p. 156. † Wilkinson's Egypt.

other public works in which metal articles were manufactured, go far to explain that interesting portion of Scripture—the early journeyings of the Israelites in the wilderness—and illustrates the ability they seem to have possessed of working in metals. The ease with which the casting and working into shape such articles as the calf, the serpent, and the more elaborate works connected with the ark, show that the Israelites had not been employed solely in the labour of brick-making while in Egypt. But before entering upon an inquiry into the construction of these works of art, made in bronze, for the ark of Moses and the temple of Solomon, we will describe the manufacture of bronze, and refer to some of the difficulties, and then compare what we can do with what evidently they did.

Bronze, as before stated, is a mixture of copper and tin, in variable proportions; but every variation in the proportions produces a bronze of different quality, more or less suitable for different purposes. One quality will have great hardness, and be, at the same time, very brittle—another, hard and flexible. One gives a bright reflecting surface when polished, suitable for mirrors, and another is famous for its sonorous qualities, and suited for bells. Before all these properties and different qualities could have been found out, a long time must have intervened; and the knowledge of these facts could not have been obtained until society had reached a great advancement in the arts.

To make good bronze, requires great care and attention in the operation of mixing the two metals. It is something more than merely fusing a certain quantity of cop-

per and tin together; or, as is generally supposed to be the case, fusing copper and adding some tin to it. To get a good homogeneous alloy, hard and tough, the tin ought to be mixed with due proportions of copper, and cast into blocks, and that alloy remixed with more copper, and this probably several times, should there be no old bronze to add to the mixture. If the copper or tin have impurities in them, they will not make good bronze for standing fatigue.

Again, the tendency of the two metals, when in the liquid state, to partially separate and settle in different strata, affects much the quality of the bronze; and it requires great skill and care to avoid this, by watching the particular heat in casting, and also by *poleing*, as described for refining copper; that is, by inserting poles of green wood into the melted mass, which causes violent ebullition, and prevents oxidation and loss. All these circumstances and conditions being required for making good bronze, to make such an article, consequently requires long practice. A knowledge of all these requirements must have been possessed by the ancients before they could obtain such bronze as they made, and which is still found in a variety of shapes, bearing evidence to the great skill of the people who produced them.

It now remains for us to show, that the bronze of the ancients, as proved by the uses they applied it to, and the analyses now made of it, was such as requires from us a great amount of knowledge and skill, as well as pure materials, to imitate; and, consequently, that the ancients must have attained to this skill and knowledge

before they could produce such articles. It may be remarked, however, that bronze used for coins, casting figures, and such like, does not require to be so pure as that required for cutting instruments used either in trade or war. Alloys that will melt at a lower heat, and be easier cast, will suit better; and we find this to have been practised by the ancients.

We will now add what analyses we have seen of these ancient bronzes, and their probable use, so far as can be suggested. This part of the subject, we are sorry to say, is very meagre, compared with what might have been done with the facilities now possessed, seeing we have so many articles both from Egypt, Babylon, and Nineveh. The first is a chisel, already referred to, found by Wilkinson in an ancient quarry in Egypt. It gave—

Copper,	94·0
Tin,	5·9
Iron,	·1
	100·0

Dagger, analysed by Klaproth—

Copper,	91·6
Tin,	7·5
Lead,	·9
	100·0

Bowl or dish, from Nimroud, analysed by Dr Percy—

Copper,	89·57
Tin,	10.43
	100·00

Hook, from Nimroud, analysed by Dr Percy—

Copper,	89·85
Tin,	9·78
	99·63

Bronze, overlaying Iron, analysed by Dr Percy—

Copper, ...	88·37
Tin, ...	11·33
	99·70

"This," says Dr Percy, "was a small casting in the shape of the foreleg of a bull; it formed the foot of a stand, consisting of a ring of iron casting upon three feet of bronze. It was deeply corroded in places, and posteriorly was fissured at the upper part. A section was made, which disclosed a central piece of iron, over which the bronze had been cast. The casting was sound, and the contact perfect between the iron and surrounding bronze. It was evident, on inspection, that the bronze had been cast round the iron, and that the iron had not been let into the bronze. Some interesting considerations are suggested by this specimen.

"The iron was employed either to economise the bronze for the purpose of ornament, or because it was required in the construction. If the former, iron must have been much cheaper than bronze, and therefore, probably more abundant than has been generally supposed. No satisfactory conclusion can be arrived at on this point, from the fact that bronze antiquities are much more frequently found than those of iron, for the obvious reason, that bronze resists, much better than iron, destruction by oxidation. Although I think there are reasons to suppose that iron was much more extensively used by the ancients than seems to be generally admitted, yet, in the specimen in question, it appears to me most probable that the iron was used because it was required in the construction. And if this be true, the Assyrians teach

a lesson to many of our modern architects and others, who certainly do not always employ metals *in accordance with their special properties.* The instrument under consideration, it will be borne in mind, was one of the feet of a stand, composed of an iron ring, resting upon vertical legs of bronze. A stand of this kind must have been designed to support weight, probably a large cauldron; and it is plain that the ring portion should therefore be made of the metal having the greatest *tenacity*, and the legs of metal adapted to sustain *vertical or superior cumbent weight.* Now, this combination of iron and bronze exactly fulfils the conditions required. I do not say that a ring of bronze might not have been made sufficiently strong to answer the purpose of the ring of iron; but I do say that, in that part of the instrument, iron is more fitly employed than bronze. Moreover, the contrast of the two metals may have been regarded as ornamental."

Bell, analysed by Dr Percy—

Copper, ...	84·70
Tin, ...	14·10
	98·80

Here it will be observed that where sound is required, the tin is increased.

Dr Percy further remarks upon the general character of the metallic objects obtained by Mr Layard:—"There are numerous other objects in metal, in Mr Layard's collection at the British Museum, which are extremely interesting in respect to the mode of manufacture, and which require very accurate examination before they can be properly described by the metallurgists. The beautiful

workmanship of the vessels, which Mr Layard believes to have been used in religious ceremonials, is especially deserving of attention, and demonstrates the skill of the Assyrians in their treatment of bronze.

"One specimen particularly deserves attention. It was a thin, hollow casting, in bronze, which was attached to the end of one of the arms of the throne. This casting had evidently been chased, and, for that purpose, must have been filled with some soft material, such as pitch, which is used at the present time. In the interior there was some black matter, which, on examination, I found to burn like pitch, and leave an earthy residue, so that probably a mixture of asphaltum and earth had been employed for the purpose mentioned."*

With most of these remarks we fully agree, and will have occasion to refer to them again more fully when treating of iron, and in the general summary.

The composition of these bronzes, it will be observed, differs little from those we have given of the ancient Peruvians; and we here add a few found in our own country, analysed by Mr J. A. Phillips, which will show the same qualities adopted for similar use:—

Sword-blade found under Chertsey Bridge, Thames—

Copper,	90·00
Tin,	9·54
Iron,	·33
	99·87

Fragment of Sword-blade found in Ireland—

Copper,	91·39
Tin,	8·38
	99·77

* Layard's Nineveh and Babylon, p. 671.

Celt—

Copper,	90·18
Tin,	9·82
	100·00

"From many synthetical experiments, made by Dr Pearson, of different proportions of tin and copper, he came to the conclusion that the most fit proportion for the manufacture of weapons and tools, are—one part of tin to nine parts of copper; and the results of his analyses of different specimens are:—

1st, A Lituus, or musical wind-instrument, found in the river Witham, Lincolnshire, gave—

Copper,	88
Tin,	12
	100

2d, Spear head, which had been cast, as evident from its rough surface, figure, texture, and grain—

Copper,	86
Tin,	14
	100

This had a little silver.

3d, A Saucepan, also cast—

Copper,	86
Tin,	14
	100

4th, Scabbard—this had an iron sword within—

Copper,	90
Tin,	10
	100

Leaf-shaped Sword, analysed by Professor George Wilson—

Copper,	88·51
Tin,	9·30
Lead,	2·30
	100·11

Axe head, by Professor Wilson—

Copper,	88·05
Tin,	11·12
Lead,	·78
	99·95

Palstave or Celt, by Professor Wilson—

Copper,	81·19
Tin,	18·31
Lead,	·75
	100·25"*

The dates of the manufacture of these are not given.

These all exhibit, not only considerable skill in the manufacture of different kinds of bronze, but also a sameness of that skill flowing through society from the earliest times.

In corroboration of what has been said in reference to casting figures and medals, we give a few analyses by Mr J. A. Phillips:—

Roman As. B.C. 500—

Copper,	69·51
Tin,	7·10
Lead,	22·02
Iron,	·48
Cobalt,	·59
	99·70

* Wilson's Archeology, etc.

Semis, B.C. 500—

Copper,	62·05
Tin,	7·62
Lead,	29·35
Cobalt,	·23
Nickel,	·19
Iron,	·17
	99·61

Quandaus, B.C. 500—

Copper,	72·17
Tin,	7·17
Lead,	19·52
Iron,	·41
Cobalt,	·29
Nickel,	·20
	99·76

Alexander the Great, B.C. 335—

Copper,	86·73
Tin,	13·15
Sulphur,	·7
	99·95

Julius and Augustus Cæsar—

Copper,	78·88
Tin,	7·95
Lead,	12·80
	99·63

The nickel, cobalt, and iron, in the above analyses, must be considered as accidental impurities, not constituting any part of the alloy.

The analyses of coins might be multiplied to a considerable extent, but without adding much to the present inquiry. The composition of the coins vary considerably; and this may be caused by the scarcity of one of the metals in different ages or localities: and a scarcity

of copper and tin may have suggested the addition of an extra quantity of lead.

Tin and copper were evidently plentiful when Alexander the Great flourished, as is proved from the vast number of bronze statues said to be then made. The Roman coins now in existence prove that lead was more used by the ancients in Italy, and, consequently, less tin and copper.

The three following were analysed by Professor Wilson:—

Bronze Cauldron—

Copper,	92·80
Tin,	5·15
Lead,	1·78
	99·73

Cauldron—

Copper,	84·08
Tin,	7.19
Lead,	8·53
	99·80

Roman Camp Kettle—

Copper,	88·22
Tin,	5·63
Lead,	5·88
	99·73

There is not much similarity between these analyses, although the articles were intended for the same use; but no date being known of when they were made, the one may have been manufactured several centuries before the other; and as they may not have been made by the natives of Britain, but imported, they may each be the

product of a different country: different localities produced alloys of different qualities. The quantity of lead in two of them, shows that they may have been manufactured by the Romans, while the first was probably made by the Grecians or Phœnicians.

The construction of the ark of Moses, generally termed the Ark of the Covenant, is the first work of art of which we have any details in history; it was also the first work performed by the Israelites as a nation. Few can read over the narrative of that undertaking, viewed independent of the adverse circumstances of the Israelites—wanderers in the wilderness—without perceiving that many amongst them possessed great skill, some of whom had probably been the highest class artizans of Egypt. This skill was not confined to the men, there being also amongst the women many skilful weavers, embroiderers, spinners, and workers in other arts then common to females.

Moses, at a general meeting of the whole congregation of Israel, intimated his plan of the ark and its construction, and the means for carrying it into effect, which was heartily responded to: "They came, both men and women, as many as were willing-hearted, and brought bracelets and ear-rings, and rings, and tablets, all jewels of gold: and every man that offered, offered an offering of gold unto the Lord." *

Moses then arranged for the construction and completion of the whole work, appointing over the whole, as the overseers and superintendents, Bezaleel and Aholiab.

"And Moses said unto the children of Israel, See, the

* Exod. xxxv. 22.

Lord hath called by name Bezaleel the son of Uri, the son of Hur, of the tribe of Judah; and he hath filled him with the spirit of God, in wisdom, in understanding, and in knowledge, and in all manner of workmanship; and to devise curious works, to work in gold, and in silver, and in brass, and in the cutting of stones, to set them, and in carving of wood, to make any manner of cunning work. And he hath put in his heart that he may teach, both he, and Aholiab, the son of Ahisamach, of the tribe of Dan. Them hath he filled with wisdom of heart, to work all manner of cunning work, of the engraver,"* etc.

That these two were only the overseers, or the responsible men, who were assisted in the performance of all this kind of work by others of the Hebrews, is evident from the following:—"Then wrought Bezaleel and Aholiab, and every wise-hearted man in whom the Lord put wisdom and understanding to know how to work all manner of work for the service of the sanctuary, according to all that the Lord had commanded. And Moses called Bezaleel and Aholiab, and every wise-hearted man, in whose heart the Lord had put wisdom, even every one whose heart stirred him up to come unto the work to do it. And all the wise men, that wrought all the work of the sanctuary, came every man from his work which he made."†

To prove that the work performed by these Hebrew artizans in the wilderness shows no mean knowledge of the metallurgical arts, we will particularise a few of the articles made by them. In the first place, we notice the two cherubims and mercy-seat. The particular shape and form

* Exod. xxxv. 30–35. † Exod. xxxvi. 1, 2, 4.

of the cherubim is unknown. It is generally agreed that they had a human head, whether a body, and in human form, or of some animal, is not certain—although the representations given of these figures, which were common in Egypt at that time, have a body. However, they are all represented with wings, and such appendages were upon those placed on the mercy-seat.

"And he made the mercy-seat of pure gold: two cubits and a-half was the length thereof, and one cubit the breadth thereof. And he made two cherubims of gold, beaten out of one piece made he them, on the two ends of the mercy-seat; one cherub on the one end on this side, and another cherub on the other end on that side: out of the mercy-seat made he the cherubims on the two ends thereof. And the cherubims spread out their two wings on high, and covered with their wings over the mercy-seat, with their faces one to another, even to the mercy-seat-ward were the faces of the cherubims." *

To make a figure, whether the body was that of a beast or man, with two outstretched wings, measuring from two to three feet from tip to tip, with the hammer, out of one solid piece of gold, was no ordinary work, and a work which few, if any, artizans of the present day could accomplish.

The next piece of work was the candleabrum or lamp-stand. Its manufacture is thus described:—"And he made the candlestick of pure gold: of beaten work made he the candlestick; his shaft and his branch, his bowls, his knops, and his flowers, were of the same: and six

* Exod. xxxvii. 6–10.

branches going out of the sides thereof; three branches of the candlestick out of the one side thereof, and three branches of the candlestick out of the other side thereof: three bowls made after the fashion of almonds in one branch, a knop and a flower; so throughout the six branches going out of the candlestick. And in the candlestick were four bowls made like almonds, his knops and his flowers: and a knop under two branches of the same, and a knop under two branches of the same, and a knop under two branches of the same, according to the six branches going out of it. Their knops and their branches were of the same; all of it was one beaten work of pure gold. And he made his seven lamps, and his snuff-dishes, and his snuffers, of pure gold. Of a talent of pure gold made he it, and all the vessels thereof."*

"And this work of the candlestick was of beaten gold, unto the shaft thereof, was beaten work: according unto the pattern which the Lord showed Moses, so he made the candlestick."†

Such works speak for themselves; but our practical readers will be apt to say, Why do such work with the hammer when they could have been cast so much easier—a process they were well acquainted with? The only answer we are prepared to give is, that it was done according to order. We have no doubt but there were reasons for so distinctive an order, something significant, which has not been revealed to us.

In the formation of the laver, or large washing basin, there is a fine and significant discrimination of the kind

* Exod. xxxvii. 17-22. † Num. viii. 4.

of materials, and their proper application, as appears in the following account of its manufacture:—"And he made the laver of brass, and the foot of it of brass, of the looking-glasses of the women assembling, which assembled at the door of the congregation."* The word here translated foot, is given in the margin as cover, and the word looking-glass as *mirror*. The proportion of alloys of copper and tin given in the preceding analyses, will not make very perfect mirrors; but an increase of tin to nearly one-third that of copper, constitutes speculum metal, an alloy which makes the most perfect mirror yet known. Now, seeing that they exhibit a complete knowledge of different sorts of bronze for different purposes, it would be too contracted to limit them in their knowledge of particular proportions. And neither is it making any unfair use of the passage, to suppose that these mirrors worn by the women were made of an alloy of tin and copper suitable, and something approaching to, if not actually, speculum metal. And thus the laver and its lid or cover, in which the priests were to wash, was like glass—its cover, when raised, forming a mirror in which they could examine themselves before approaching the altar of their God.

That it was the custom for the women to wear mirrors, in those early times, as an article of dress, is verified by ancient sculpture; and the custom is strong evidence of the general use of alloys of tin and copper; and also shows the skill in adapting the proportions to the object for which it was to be applied. There were a great many other articles made of bronze, which will be men-

* Exod. xxxviii. 8.

tioned—of which nothing particular is specified. Besides these works in metal particularly alluded to, there are other works that referentially indicate a still more intimate knowledge of metals, such as the engraving of the names of the different tribes of Israel upon the precious stones, all hard—as the ruby, topas, carbuncle, emerald, sapphire, diamond, jacinth, agate, amethyst, beryl, onyx, and jasper.* The gravers were no doubt of metal, but of what sort is not known. A passage from Job is significant upon this subject: "That my words were graven with an iron pen in the rock!"†

On the value of the different metals used in the construction of the ark and its furniture, we here quote the opinion of Dean Prideaux:—

"The value of the twenty-nine talents and 738 shekels of gold, will be £198,347 12s 6d. The value of the silver contributed by 603,550 at half-a-shekel, or 1s 6d per man, will amount to £45,266 5s.

"The value of the seventy talents and 2400 shekels of brass will be £573 17s.

"The gold weighed 4245 pounds; the silver, 14,603 pounds; and the brass, 10,277 pounds troy weight. The total value of all the gold, silver, and brass, will consequently amount to £244,127 14s 6d; and the total weight of these three metals will amount to 29,124 pounds troy, which, reduced to avoirdupois weight, is equal to fourteen tons 266 pounds."‡

Taking the Scripture narrative, and the data we have already given, namely, a talent equal to 125 pounds

* Exod. xxxix. 10–15. † Job xix. 24.
‡ Quoted in Bagster's Comprehensive Bible; Exod. xxxviii.

troy, of gold worth £5475, and of silver, worth £342 3s 9d, the whole value and weight somewhat differs from the above.

"And all the gold that was occupied for the work in all the work of the holy place, even the gold of the offering, was twenty and nine talents, and seven hundred and thirty shekels, after the shekel of the sanctuary. And the silver of them that were numbered of the congregation was an hundred talents, and a thousand seven hundred and threescore and fifteen shekels, after the shekel of the sanctuary. And the brass of the offering was seventy talents, and two thousand and four hundred shekels."*

From these we make the following in round numbers—

29 talents	730 shekels	Gold,.....	..	£160,107
100 "	1775 "	Silver,.....		34,422
70 "	2400 "	Bronze,.....		
Reduced to avoirdupois pounds, @ 1s 4d per lb.,.....				485
				£195,014

The weight given here will stand as under—

Gold, ...3655 pounds		Avoirdupois, ...3007 pounds	
Silver,...12,574 "		" 10,346 "	
Bronze, ...8850 "		" 7282 "	
Total, 25,079 pounds		Avoirdupois, 20,635 pounds	

Equal in all to 9 tons, 4 cwt., and 1 qr. Upwards of three tons bronze.

It must be remembered that this includes all the metals used for outside work connected with the tabernacle, as pins for tents, hinges, sockets, curtain rings, etc. If we include the weight and bulk of the curtains, and all

* Exod. xxxviii. 24-29.

the necessary furniture, the number of Levites required to carry the whole from place to place must have formed an imposing multitude. The ark and its contents was not so formidable alone, as it was carried between spokes or staves and by a few priests; in Samuel's time a cart was used, the whole being drawn by two milk cows.*

That the Hebrews had such a quantity of metal at that time strikes a casual reader with surprise, but it must be remembered they numbered about 6,000,000; and on leaving Egypt, they had individually obtained from their Egyptian neighbours jewels and ornaments of various sorts; besides, we cannot suppose them entirely destitute of such things, as they had but recently conquered the Amalekites, etc., from whom they no doubt had taken much spoil. The manner in which the collection for the ark was made, indicates that many Hebrews had metals in great abundance, and the collection made at the numbering of the people, mentioned in the following passage, proves this: "Every one that passeth among them that are numbered, from twenty years old and upward, shall give an offering unto the Lord. The rich shall not give more, and the poor shall not give less than half a shekel when they give an offering to the Lord."† This refers to silver, and shows that its possession was universal, and the demand such that it was not above the means of the poorest, and, at the same time, far below that of the wealthy. The whole would form a sum somewhere about £38,000. After the formation of the ark, it does not appear that

* 1 Sam. vi. † Exod. xxx. 14, 15.

the Hebrews were called upon again publicly to exercise their skill in the arts. Their forty years' wandering rendered such a call quite unnecessary. During that time all those who had learned these arts in Egypt must have died, and with them, in all probability, passed away much of the ingenuity and skill from the people; and except in making weapons of war, and probably instruments for agriculture, the Hebrews, for several centuries, were so much engaged in taking possession of their land, in wars and fightings, that the ordinary arts of civilised life could not be cultivated; consequently, notwithstanding the enormous wealth they had accumulated in the time of David, when his son Solomon began to erect the temple, (a work which their forefathers, when they left Egypt, could have done without assistance,) skilled workmen could not be obtained amongst all the Hebrews—there were none who could undertake the superintendence or do the skilled work of the casting and working in metals. Although the higher classes of Israel were great in wealth, yet amongst them were but few artizans, and no Bazaleels or Aholiabs—cunning workers in all kinds of gold and silver, blue and purple, etc.; such men had to be obtained from another country. There were, however, masons and carpenters, and such as were essential in a country, even in times of war; but the higher class of artizans had declined amongst them. David says: "Moreover, there are workmen with thee in abundance, hewers and workers of stone and timber, and all manner of cunning men for every manner of work."* Many of these referred to

* 1 Chron. xxii. 15.

were no doubt Hebrews, but we think it more than probable that a great many of them were captives taken by David, and kept by him for this great work, which is somewhat proved by the following passage referring to this. When Solomon is negotiating with the king of Tyre for men and materials, he says: "Send me now therefore a man cunning to work in gold, and in silver, and in brass, and in iron, and in purple, and crimson, and blue, and that can skill to grave with the cunning men that are with me in Judah and Jerusalem, whom David my father did provide."* And this is made more evident when taken in connection with the following passage: "And Hiram, king of Tyre, sent messengers to David, and cedar trees, and carpenters, and masons, and they built David an house."† These passages show the low state to which the Israelites must have been reduced at that period.

In a former part of this volume, some idea of the great amount of the precious metals provided and applied to the fitting up of the temple was given; but there is no statement by which we can determine the quantity of bronze used in this vast structure; indeed, either from the vastness of the amount or quality, or from its being of so comparatively little value, we find it stated: "And Solomon left all the vessels unweighed, because they were exceeding many: neither was the weight of the brass found out;"‡ and again,—"Thus Solomon made all these vessels in great abundance: for the weight of the brass could not be found out;"§ evidently from their

* 2 Chron. ii. 7. † 2 Sam. v. 11. ‡ 1 Kings vii. 47.
§ 2 Chron. iv. 18.

number and size, many of which were of immense weight. It is impossible for any one to read over the graphic account given of the temple, especially of the productions in metal, and that which would require metals to accomplish, without being struck, not only with the vast quantities and large castings, but the great variety of the work done: a few of which are here enumerated.

The first to be mentioned are the two bronze pillars, the dimensions of which will be given in English measure, taking the cubit to be equal to twenty-one inches, the measurement which most of Biblical critics consider to be correct. In the dimensions of these pillars, there is some discrepancy in the account given of them: "For he cast two pillars of brass, of eighteen cubits high a piece: and a line of twelve cubits did compass either of them about. And he made two chapiters of molten brass, to set upon the tops of the pillars: the height of the one chapiter was five cubits, and the height of the other chapiter was five cubits."* Again: "Also he made before the house two pillars of thirty and five cubits high, and the chapiter that was on the top of each of them was five cubits."† Commentators have endeavoured to reconcile these discrepancies.‡ The first is the measurement that is generally agreed upon, and which we adopt. The pillars without the capitals measured 32½ feet long and seven feet diameter, and if hollow, as Whiston thinks they were in his translation of Josephus, the metal would be about 3½ inches thick; so that the whole

* 1 Kings vii. 15, 16. † 2 Chron. iii. 15.
‡ See, for instance, Kitto's Pictorial Bible.

casting of one pillar must have been from sixteen to twenty tons.

The height of the capitals were $8\frac{3}{4}$ feet, and, at the same thickness of metal, would not weigh less than seven or eight tons each. As to the nature of the workmanship in the finishing of these capitals with the pillars, every practical man will be able to appreciate from the following description:—

"And nets of checker work, and wreaths of chain work, for the chapiters which were upon the top of the pillars; seven for the one chapiter, and seven for the other chapiter. And he made the pillars, and two rows round about upon the one network, to cover the chapiters that were upon the top, with pomegranates: and so did he for the other chapiter. And the chapiters that were upon the top of the pillars were of lily work in the porch, four cubits. And the chapiters upon the two pillars had pomegranates also above, over against the belly which was by the network: and the pomegranates were two hundred in rows round about upon the other chapiter. And upon the top of the pillars was lily work: so was the work of the pillars finished."*

The pillars, when set up, would stand forty feet in height.

The next great work was the bronze altar, which measured 35 feet by 35, and in height $17\frac{1}{2}$ feet; it is thus described: "Moreover he made an altar of brass, twenty cubits the length thereof, and twenty cubits the breadth thereof, and ten cubits the height thereof."† The thickness of the metal used for this altar is nowhere

* 1 Kings vii. 17–22. † 2 Chron. iv. 1.

given, but supposing it to have been three inches, the whole weight of the metal would not be under 200 tons.

The next large casting is that termed the molten sea: "Also he made a molten sea of ten cubits from brim to brim, round in compass, and five cubits the height thereof; and a line of thirty cubits did compass it round about. And under it was the similitude of oxen, which did compass it round about: ten in a cubit, compassing the sea round about. Two rows of oxen were cast when it was cast. And the thickness of it was an handbreadth, and the brim of it like the work of the brim of a cup, with flowers of lilies; and it received and held three thousand baths."*

This immense semicircular vessel would therefore measure $17\frac{1}{2}$ feet diameter, and be $8\frac{3}{4}$ feet deep—this, at $3\frac{1}{2}$ inches, could not weigh less than from twenty-five to thirty tons in one solid casting—and held from 16,000 to 20,000 gallons of water. The brim was all carved with lily work or flowers, and oxen were carved or cut on the outside all round, to the number of 300, and it stood upon a pedestal of twelve bronze oxen :—"It stood upon twelve oxen, three looking toward the north, and three looking toward the west, and three looking toward the south, and three looking toward the east: and the sea was set above upon them, and all their hinder parts were inward."†

The size of these oxen or bulls are not given, but they must have been of considerable size, so as their corresponding legs would give thickness or strength to support so great a weight, for when the vessel was filled

* 2 Chron. iv. 2, 3, 5. † 2 Chron. iv. 4.

with water, the whole weight would be about 100 tons: how appropriate would such legs be as described by Dr Percy, and found by Mr Layard, where iron was overlaid with bronze.

There were also castings of a smaller sort, the details of which, as given by the sacred narrator, shows them to have been castings of very great size, as for instance:—"And he made ten bases of brass; four cubits was the length of one base, and four cubits the breadth thereof, and three cubits the height of it. The work of the bases was on this manner: they had borders, and the borders were between the ledges: and on the borders that were between the ledges were lions, and oxen, and cherubims: and upon the ledges there was a base above: and beneath the lions and oxen were certain additions made of thin work. And every base had four brazen wheels and plates of brass: and the four corners thereof had undersetters: under the laver were undersetters molten, at the side of every addition. And the mouth of it within the chapiter and above was a cubit: but the mouth thereof was round after the work of the base, a cubit and an half: and also upon the mouth of it were gravings with their borders, foursquare, not round. And under the borders were four wheels; and the axle-trees of the wheels were joined to the base: and the height of a wheel was a cubit and half a cubit. And the work of the wheels was like the work of a chariot wheel: their axle-trees, and their naves, and their felloes and their spokes, were all molten. And there were four undersetters to the four corners of one base: and the undersetters were of the very base itself. And in the

top of the base was there a round compass of half a cubit high: and on the top of the base the ledges thereof and the borders thereof were of the same. For on the plates of the ledges thereof, and on the borders thereof, he graved cherubims, lions, and palm trees, according to the proportion of every one, and additions round about. After this manner he made the ten bases: all of them had one casting, one measure, and one size."*

These bases fitted, upon wheels, constitutes carriages for supporting and moving about the ten lavers, or large bronze vessels for washing, etc. The whole workmanship of these bases, as described, is indicative of great skill. The lavers are thus described: "Then made he ten lavers of brass; one laver contained forty baths, and every laver was four cubits, and upon every one of the ten bases was one laver."† When it is considered that each of these vessels were capable of holding 300 gallons of water, upwards of a ton weight, we obtain a better idea of their size. The whole, when full of water upon the carriage, would be no less than two tons. We need not specify more of these large works done for the temple; those named are sufficient to verify what has been stated in reference to the knowledge in working in bronze possessed by these artizans, and which we will have occasion to refer to again; as regards their mode of effecting these extensive works, it will lessen the surprise felt when reading the statement, that the weight of the brass was not known from its abundance. That different qualities of bronze were made and used for different purposes, both for beauty and being more

* 1 Kings vii. 27–37. † 1 Kings vii. 38.

suitable, is apparent from the following general statement: "And the pots, and the shovels, and the basins: and all these vessels, which Hiram made to king Solomon for the house of the Lord, were of bright brass."* This, we think, refers to their either being polished, or made of a different quality—whiter, or probably both.

Whoever reads over the description given of the work done in metal for the temple, with any care, will form no mean conception of the skill of the ancients in the metallurgical arts, not only in casting, but engraving, carving, and probably chasing, and every delicate operation in metals. It will also be apparent, in reading over the account of these enormous castings, that vast mechanical resources must have been also within their reach, to remove, fit up, and place in position, such vast masses of metal.

When another circumstance in connection with these large castings is considered—the question arises, where were they cast, and in what kind of moulds? In reply to such questions, there is the following statement: "In the plain of Jordan did the king cast them, in the clay ground between Succoth and Zarthan."* According to the marginal reading, the translation should be: "In the depth of the clay ground," showing that they had been moulded in clay. Some have suggested that they were done out of Jerusalem for sanitary considerations;* but we must be content with the reason suggested by the historian. Clay and sand mixed are the moulding material still

* 1 Kings vii. 45. † 1 Kings vii. 46.
‡ See Marginal Reference to the passage in Bagster.

used for bronze. Such large quantities of metal as one of these castings would contain, could not be fused in one furnace; but would require a series of furnaces, especially for such a casting as the SEA OF BRASS,—the whole series of furnaces being filled with metal, and fused at one time, and all tapped together, and the metal let run into the mould. Such series of furnaces are generally constructed in a sort of circle or square, under one large dome or roof, forming a large chimney or tower. Such structures are generally in the neighbourhood of towns, and always form a very conspicuous object. Now, if a similar method was adopted in these early days, it may illustrate the reference of Nehemiah, in the following passage:—"Malchijah the son of Harim, and Hashub the son of Pahath-moab, repaired the other piece, and the tower of the furnaces."* This may refer to such structures as we have just been referring to as having been on the plains of Jordan, erected in the time of Solomon, and may have continued a place for metallurgical operations—a national foundry—up to the time the Jews were carried captive into Babylon. And again, in the restoration, or rather rebuilding of the temple, these same metallurgical operations would be resumed, and hence the repairing of these furnaces would form an important object to the returning captives; and as they were coming out from the midst of a people well skilled in metallurgical operations, as is made evident by such works as the golden image in the plains of Dura, and as the researches of Layard and others have fully verified. It is probable that many of the returning Jews were

* Neh. iii. 11.

also well instructed in these fine arts. When we consider the enormous quantity of bronze which must have been used in the construction of the temple, and that at least about ten per cent. of the whole was tin, we can easily conceive the abundance of this metal at that period. And to us it has a still greater interest, from the circumstance that, in all probability, most of the tin used for the work of the temple was found in our own island. At least, it is all but certain, that the Phœnicians, in the days of David and Solomon, wrought the mines of Cornwall and Devonshire for tin; but it is stated by historians, that they studiously kept the locality where they obtained the tin a secret, being monopolisers of wealth—although, wherever they went, they introduced trades, industry, and commerce, and thus sowed the seeds of civilisation. The tin imported by them, and sold to other nations, was no doubt a source of great revenue to the nation. Such metal could not be cheap, from the nature of the trade. According to Pliny, they supplied the ancient Romans with the same metal at about eight shillings per avoirdupois pound. If, therefore, it was near that value in the time of Solomon, the quantity used would amount to a vast sum of money. As tin is not named separately in connection with the temple, it is probable the Phœnicians made and sold the bronze.

The knowledge of the art of working in metals being again introduced into Palestine by the Tyrians or Phœnicians at the building of the temple, it never seems to have declined afterwards, for we find here and there many references in Scripture to smiths and other artificers

in metal; and also of different kinds of work done amongst themselves, requiring considerable skill. Yet, except at these two periods, the Hebrews, as a nation, never appear to have been a manufacturing people, and never excelled in works of art.

History does not furnish us with any account of a single building upon which there was such an expenditure of metals of all kinds as the Temple of Solomon; and seeing that such vast treasures, accumulated in one building, were well calculated to excite the cupidity, not only of wicked and extravagant rulers, but of other nations, it will be of interest to ascertain, if possible, what became of such a vast quantity of metal thus brought together into the house of the Lord.

The temple was commenced in or about the year 1011 B.C., and forty-one from this date, 970 B.C. Shishak, king of Egypt, captured Jerusalem, and plundered the temple and palace of much gold, taking away the shields and targets of gold, which were afterwards replaced by targets and shields of bronze:—"And it came to pass in the fifth year of king Rehoboam, that Shishak, king of Egypt, came up against Jerusalem: and he took away the treasures of the house of the Lord, and the treasures of the king's house; he even took away all: and he took away all the shields of gold which Solomon had made. And king Rehoboam made in their stead brasen shields, and committed them unto the hands of the chief of the guard, which kept the door of the king's house."* This spoliation seems to have extended to more things than the articles enumerated here.

* 1 Kings xiv. 25-27.

Although the cost of the targets and shields would be somewhere about £239,000, it is said *he took all*—probably meaning all that was required to pay his expenses—not all that was in the house.

In the meantime, Judah had been led into idolatry by the mother of the king, whom Asa removed from being queen, put down her idolatries, destroyed her idol, stamped it, and burned it, and turned his heart to the worship of God: "And he brought into the house of God the things that his father had dedicated, and that he himself had dedicated, silver, and gold, and vessels."* And this king reigned peaceably until near the close of his life. †

In 920 B.C., when Asa was besieged by the king of Israel, he made free use of the treasures of the temple, to bribe the king of Syria to assist him against Israel: "And Baasha, king of Israel, went up against Judah, and built Ramah, that he might not suffer any to go out or come into Asa, king of Judah. Then Asa took all the silver and the gold that were left in the treasures of the house of the Lord, and the treasures of the king's house, and delivered them into the hand of his servants: and king Asa sent them to Ben-hadad the son of Tabrimon, the son of Hezion, king of Syria, that dwelt at Damascus, saying, There is a league between me and thee, and between my father and thy father: behold, I have sent unto thee a present of silver and gold; come

* 2 Chron. xv. 18.

† Asa reigned forty or forty-one years, beginning in the twentieth of Jeroboam, (1 Kings xv. 9, 10; 2 Chron. xvi. 13; A.M. 3049; B.C. 955.) See Sandford's Chronology of the Old Testament. His Chronology is the one followed in the text.

and break thy league with Baasha, king of Israel, that he may depart from me." *

From neglect, and probably other spoilations, not particularly recorded, and from idolatry, the temple, or certain portions of it, suffered great injury: "For the sons of Athaliah, that wicked woman, had broken up the house of God; and also all the dedicated things of the house of the Lord did they bestow upon Baalim." † Under these circumstances, a voluntary contribution was made for the temple and its repairs, and this was carried out about 878 B.C.: "And thus they did, day by day, and gathered money in abundance. And the king and Jehoiada gave it to such as did the work of the service of the house of the Lord, and hired masons and carpenters to repair the house of the Lord, and also such as wrought in iron and brass, to mend the house of the Lord. So the workmen wrought, and the work was perfected by them, and they set the house of God in his state, and strengthened it. And when they had finished it, they brought the rest of the money before the king and Jehoiada, whereof were made vessels for the house of the Lord, even vessels to minister, and to offer withal, and spoons, and vessels of gold and silver." ‡ These were no doubt to supply the place of many that had been taken away by Athaliah.

When (about 3262 A.M.) king Ahaz visited the king of Assyria, he saw at Damascus an altar of superior workmanship that pleased him so much, that he sent a pattern or drawing of it to Jerusalem, with orders to have one made for him exactly similar, on his return, that he might wor-

* 1 Kings xv. 17-19. † 2 Chron. xxiv. 7. ‡ 2 Chron. xxiv. 11-14.

ship thereon: "And king Ahaz went to Damascus to meet Tiglath-pileser, king of Assyria, and saw an altar that was at Damascus: and king Ahaz sent to Urijah the priest the fashion of the altar, and the pattern of it, according to all the workmanship thereof. And Urijah the priest built an altar, according to all that king Ahaz had sent from Damascus: so Urijah the priest made it against king Ahaz came from Damascus. And when the king was come from Damascus, the king saw the altar: and the king approached to the altar, and offered thereon. And he brought also the brasen altar, which was before the Lord, from the forefront of the house, from between the altar and the house of the Lord, and put it on the north side of the altar."* This was followed immediately by a sacrilegious act of the grossest kind: "And king Ahaz cut off the borders of the bases, and removed the laver from off them; and took down the sea from off the brasen oxen that were under it, and put it upon a pavement of stones."†

Dr Kitto, in his History of Jerusalem, thinks that these bases, and also the twelve oxen, were melted down for other, and probably idolatrous purposes. That the latter were not melted, is evident from their being named by Jeremiah amongst the articles taken away to Babylon—which will be again referred to. Probably the oxen were used, as such, for some idolatrous object. I am inclined to think that, along with the borders of the bases cut off, the metal of the large bronze altar was also used up by Ahaz for altars or idols about the City of Jerusalem, for the temple was shut up: "And Ahaz gathered

* 2 Kings xvi. 10-14. † 2 Kings xvi. 17.

together the vessels of the house of God, and cut in pieces the vessels of the house of God, and shut up the doors of the house of the Lord, and he made him altars in every corner of Jerusalem."*

In the next king's reign, Hezekiah, the temple was again opened and cleaned, and the vessels which Ahaz had cast aside and polluted, were also purified:—"Moreover all the vessels, which king Ahaz in his reign did cast away in his transgression, have we prepared and sanctified, and, behold, they are before the altar of the Lord."† And in corroboration of the assertion that idols were set up in the city, it is stated: "He (Hezekiah) removed the high places, and brake the images, and cut down the groves, and brake in pieces the brasen serpent that Moses had made: for unto those days the children did burn incense to it: and he called it Nehushtan."‡ This is stated in the margin to mean a "*piece of brass*:" possibly Hezekiah got the brasen sea replaced upon the oxen, as it was before.

About 3408 A.M. (B.C. 596) Nebuchadnezzar, after a protracted siege, reduced Jerusalem, destroyed the temple, and carried away most of the metals to Babylon: "And the pillars of brass that were in the house of the Lord, and the bases, and the brasen sea that was in the house of the Lord, did the Chaldeans break in pieces, and carried the brass of them to Babylon. And the pots, and the shovels, and the snuffers, and the spoons, and all the vessels of brass wherewith they ministered, took they away. And the firepans, and the bowls, and such things as were of gold, in gold,

* 2 Chron. xxviii. 24. † 2 Chron. xxix. 19. ‡ 2 Kings xviii. 4.

and of silver, in silver, the captain of the guard took away. The two pillars, one sea, and the bases which Solomon had made for the house of the Lord; the brass of all these vessels was without weight."* Jeremiah says: "And the basons, and the firepans, and the bowls, and the caldrons, and the candlesticks, and the spoons, and the cups; that which was of gold in gold, and that which was of silver in silver, took the captain of the guard away. The two pillars, one sea, and twelve brasen bulls that were under the bases, which king Solomon had made in the house of the Lord: the brass of all these vessels was without weight."† The large bronze altar is not here mentioned. Whether the gold used in overlaying the house, and in making up the furniture of the temple, was all removed previous to this, is not certain; but from what is stated, it would appear that much gold remained. The removing of such a vast quantity of metal to Babylon must have been a formidable undertaking, and it is exceedingly interesting thus to trace great and precious relics.

The sacred vessels of gold and silver were preserved from destruction, and carried by the Assyrians to Babylon, who placed them in the temple of their idols. But in a very few years after the removal of the gold, silver, and brass from the temple in Jerusalem, "Nebuchadnezzar the king made an image of gold, whose height was threescore cubits, and the breadth thereof six cubits: he set it up in the plain of Dura, in the province of Babylon."‡

This took place in so short a time after the fall of

* 2 Kings xxv. 13-16. † Jer. lii. 19, 20. ‡ Dan. iii. 1.

Jerusalem, as to suggest that the image was likely to have been made from the metal removed from that city. The siege had been a formidable undertaking, and of sufficient importance to warrant a memorial being erected. And this image set up in Dura was, in all probability, not only for worship, but also in commemoration of the defeat of the Jews and the taking of Jerusalem. This gives the reason why the Jews were watched during its dedication, and why the three young patriots did not go to the dedication of the image—being not only an acknowledgment of the superiority of the Assyrian gods over the God of Israel, but a rejoicing at their own defeat. The inquiry is also interesting at the present day, from the probability that many of the bronze articles found by Mr Layard and others in the ruins of Babylon, may have been either a part of the furniture of the temple, or made from the bronze formerly in the Temple of Solomon.

It is curious that no notice is taken of the ark of the covenant in the destruction of the temple—whether it was removed or destroyed. If either had taken place, it is more than probable that such an event would have been referred to by Jewish historians, as their great reverence for this object would have induced them to have lamented either its destruction or removal to Babylon. We are inclined to think that this sacred vessel was perhaps hid by pious priests, who, seeing certain destruction coming upon them during the protracted siege, removed it to a place of safety, and their death following, the locality of its hiding-place was forgotten.

When the Jews returned from Babylon to their

own land, B.C. 536, they obtained permission to carry back with them the sacred vessels of their temple, which had been kept in the temples of Babylon since their captivity—thus narrated by the historian of that event: "Also Cyrus the king brought forth the vessels of the house of the Lord, which Nebuchadnezzar had brought forth out of Jerusalem, and had put them in the house of his gods; even those did Cyrus, king of Persia, bring forth by the hand of Mithredath the treasurer, and numbered them unto Sheshbazzar, the prince of Judah. And this is the number of them: Thirty chargers of gold, a thousand chargers of silver, nine and twenty knives, thirty basons of gold, silver basons of a second sort four hundred and ten, and other vessels a thousand. All the vessels of gold and of silver were five thousand and four hundred. All these did Shethbazzar bring up with them of the captivity that were brought up from Babylon to Jerusalem."*

The most, if not all of these, remained in the second temple, until it was destroyed by Titus after the Christian era, and were carried in triumph into Rome—as Josephus, who was an eye-witness, testifies:—"But for those that were taken in the Temple of Jerusalem, they made the greatest figure of them all. The golden table, of the weight of many talents; the candlestick that was made of gold, though its construction was now changed from that which we made use of—for its middle shaft was fixed upon a bases, and the small branches were produced out of it to a great length, having the likeness of a trident in their position, and had every one a socket

* Ezra i. 7-11.

made of brass for a lamp at the top of them; these lamps were in number seven, and represented the dignity of the number seven amongst the Jews."* The figure of the candlestick was sculptured on the triumphal arch of Titus, which is still to be seen.

When Genseric sacked Rome, A.D. 455, he took the candlestick with him to Carthage, and Belisarius found it there when he defeated the Vandals; he brought it to Constantinople, where it was deposited, with other vessels of the Jewish temple, in the Christian Church of Jerusalem,† A.D. 534. This is the last notice taken of it in history. It is possible that it may yet be found, and if found, the candlestick would certainly form one of the most interesting objects of antiquity.

* Josephus' Wars with the Jews, Book vii.; Whiston's Translation.

† Gibbon's History of the Decline, etc. of the Roman Empire, chapter 41. Mr J. Nicholson (Kitto's Cyclopædia, article Candlestick,) maintains that it was sent off to Jerusalem from Constantinople.

LEAD.

LEAD is seldom found in the earth in a metallic state, and only in very small quantities; but it is found in great abundance as a mineral, in combination with other substances, especially with sulphur. The ores of lead are very heavy, and are white, green, or blue, especially the latter. Wherever a knowledge of smelting ores has existed, and if lead ores were found near, it could not fail to attract immediate attention; consequently, we find lead noticed at a very early period.

The mode of extracting the metal from the ore is somewhat similar to that described for copper and tin. The ore is generally found in veins of rocks, and has to be dug out in masses, which are often mixed with earthy matters. These masses are broken into small pieces and then crushed fine, and the whole washed in a stream of water, which carries away the greater part of the earthy matters, owing to their being lighter than the lead ore. The remaining ore is collected and dried, then subjected to the operation of smelting. Were the ore an oxide—that is, a combination of oxygen and lead—then mixing it with coal and heating in a furnace to reduce it, would liberate the metal, which would be obtained at the bottom of the furnace, or vessel, in which it was so heated. The ore is seldom in this state, but mostly as a sul-

phuret—that is, lead and sulphur combined—in which case it is subjected to a low, red heat, in a free current of air: a small portion of the sulphur is driven off in this operation, while another portion combines with oxygen and forms a sulphate, which, by increasing the heat of the furnace, is decomposed by reacting upon other portions of ore; and thus all the lead in the ore is reduced to the state of metal without mixing the ore with coal. This is done in a furnace of a particular construction—termed the reverberatory. This is the process by which lead ore is smelted at the present time. It will be evident, at the same time, from what has been stated, that if all the sulphur was driven off from the ore by heat and air, so that the lead was all converted into an oxide, the heating of this oxide with carbonaceous matters mixed with it, would reduce the lead to the state of metal. The sulphuret of lead may also be reduced by putting it into a furnace or crucible along with flux—such as soda or potash—or mixing with it metallic iron. These last processes, however, are not profitable, and not applied on the large scale. Whether any of these processes were adopted by the ancients for obtaining the metal (lead) from the ore, we have no reference either in sacred or profane history, except the obscure notice of Pliny, already referred to. (page 75.)

The ores of lead are widely diffused throughout nature; and it is known to have existed in considerable quantity in the neighbourhood of Sinai, and also near Egypt, between the Mediterranean and the Nile*—hence the

* Kitto's Physical Palestine, lxxiii.

supply to Egyptians and Israelites was of easy access—and is quite consistent with the early notice of that metal in Scripture. It is first mentioned, in respect to time, in the following words:—"O that my words were now written! O that they were imprinted; that they were engraven with an iron pen in the lead in the rock for ever!"* This reference clearly indicates that lead was not only well known, but applied to some of the fine arts; this application is supposed to refer to an inscription engraved on stone, and filled up with lead—a beautiful application for the preservation of the writing. The next reference to lead is in Moses' triumphal song, celebrating the overthrow of Pharaoh: "They sank as lead in the mighty waters"†—a familiar expression, the same as our saying, "as heavy as lead," etc.—expressions which clearly prove that lead was in common use, and its common physical property well known. It is next mentioned amongst the spoils taken by the Israelites from the Medianites: "The gold, and the silver, the brass, the iron, the tin, and the lead;"‡ evidence that it was held in considerable value amongst the Hebrews. The various objects, in the manufacturing of which the metal was then used, are not mentioned in Scripture, except an indication that it was used for weights: "And he cast it into the midst of the ephah; and he cast the weight of lead upon the mouth thereof."§ The extreme softness of lead, the ease with which it tarnishes, its want of sound, and other general properties, are against its being used for domestic

* Job xix. 23, 24. † Exod. xv. 10. ‡ Num. xxxi. 22.
§ Zech. v. 8.

purposes. Pliny mentions that it was used in his day, and before his time, for water-pipes, as at present; and that sheet lead was used for covering articles for their protection. Mention is also made of its being used for writing-tables, but whether applied to these objects by the Egyptians or Hebrews in the earlier ages of their history, is not certain; but we think it more than probable, that it was used even in the days of Moses for similar purposes. As showing the extent of its use, and its enormous quantity in ancient times, I will here quote what is stated by historians in reference to the stupendous hanging gardens of Babylon.

"The level of each terrace was then formed in the following manner: The top of the piers were first laid over with flat stones, sixteen feet in length and four feet in width; on these stones were spread beds of matting, then a thick layer of bitumen, after which came two courses of bricks, which were covered with sheets of solid lead."*

Lead ore is found abundant in Britain, and there is every evidence that the lead mines of this country were wrought by the ancient Romans, and probably also formed a part of the traffic of the Phœnicians. Sir R. Murchison says, that "lead cast in Roman moulds, *pigs*, in fact, of the age of Hadrian and other emperors, have been found in Fifeshire, Derbyshire, Yorkshire, and some other counties. The shape of the ingots or pigs are nearly the same as at the present day, and the inscriptions are made in raised letters on the top." If these letters were made in the mould, and thus appear

* Kitto's Cyclopædia, article Babylon.

raised on the top, one wonders that this did not suggest the idea of printing. We copy one of these as given by Mr J. Phillips:—"A third with the inscription, also in raised letters on the top, was found on Matlock Moor, in the year 1787. It weighed 173 lbs., and was seventeen and a-half inches in length, and at bottom twenty and a-half. The inscription was, TI. CL. TR. LVT. BR. EX. ARG."*

Under the metal, Silver, it has been shown that lead was used in the earliest times for purifying silver in the same manner as we do it in the present time, namely, mixing lead with silver and melting them upon a cupel, or flat vessel made of bone earth, and then oxidising the lead by blowing upon the surface of the fused mass, when the silver was left pure—a process already detailed in full, and the references made to this process in Scripture have also been given. Having established the fact that lead was used for purifying silver, and knowing that the greater portion of lead ore contains silver—sometimes in considerable quantity, and that it is in the present day an important source of that metal, we are, in my opinion, warranted in believing that this fact would necessarily become known to the ancients; and that their lead ores were also a source of silver to them, and may have been an important source. Pliny, as before quoted, states that the ore of lead is found mixed with silver in the same mine.

In all probability, the Phœnicians were also extensively engaged in lead smelting, or, if smelted by the natives near the mines, bought by them, and imported

* Glover's Derbyshire.

in the same way as they did with tin; it is mentioned, along with tin, as an article sold in their markets: "With silver, iron, tin, and lead, they traded in thy fairs."* The general familiar tone in which lead is always referred to in Scripture, makes us believe that it was extensively used in many of their manufactures.

In the purifying of silver with lead, they necessarily would form litharge, or oxide of lead. This oxide, when heated with coal or carbonaceous matters, produces metal again—a process which would undoubtedly be practised in these early days for recovering their lead thus oxidised. But this litharge is extensively used by us in making salts of lead, paints, glazes, and also glass. Some of the glazes upon articles of pottery, and the paints on the clay vessels found in ancient Egypt and Nineveh, have been analysed, and found to contain oxide of lead; in other words, to be composed of the same materials as that which we now use for the same purposes, and which, until lately, was considered an invention of our own time. It is considered by many that the ancients were unacquainted with the making of transparent glass; but from what has been said in respect to these glazes—the scoria necessarily formed in smelting, etc.—we see that they must have been long bordering upon that invention. That they made glass, is proved by many articles still in existence—such as the Portland vase, etc.—which is more of the nature of glass than pottery, although opaque; and Wilkinson has almost proved that the ancient Egyptians were eminent glass-blowers.†

Lead is also used by us along with tin for soldering

* Ezek. xxvii. 12. † See Appendix.

metals together. Although the Scripture does not mention the composition of solder, yet the fact that soldering metals was practised, is evident from the following passage: "So the carpenter encouraged the goldsmith, and he that smootheth with the hammer him that smote the anvil, saying, It is ready for the soldering: and he fastened it with nails, that it should not be moved."* This is another beautiful description of a practical process in metallurgy, and is similar to the method now practised in soldering two pieces of metal; after being smoothed and prepared, they are fastened together by iron clasps, or holders for soldering. The word, nails, according to the margin, is a mistranslation—meaning holder or clasp. It is also a fine description of the division of labour—a system not only economical, but calculated to make the finest work, and the most expert workmen. The nature of the solder used is not indicated in the passage, but the term goldsmith being used, shows that the article referred to as being soldered, may belong to the precious metals; and solder for these metals is generally made of copper, silver, and tin, or such alloy that melts at a lower heat than the metals soldered. The passage, however, states the practice, and indicates a general use, and this has been verified by articles found in ancient Egypt that had been soldered. And Wilkinson says: "In coarser work, or in those parts which were out of sight, the Egyptians soldered with lead. The oldest specimen of metal soldered which I am acquainted with, is the sistrum of Mr Burton—its date is uncertain; and though,

* Isa. xli. 7.

from the style of the figures engraved upon it, we may venture to ascribe it to a Pharaohnic age, the exact period when it was made cannot be fixed."* Pliny states that lead was used for soldering lead and other articles. Lead, however, cannot be used alone for this purpose without tin in it, which makes it much more easily fused. An alloy such as this, which has the appearance and property of lead, would readily be termed lead by any party not knowing the technicalities of the trade. It is therefore probable that the solder used in early times for lead, and termed lead, was the same as is now used—a mixture of lead and tin. For another use for lead we have the following statement: "Thus he shewed me: and, behold, the Lord stood upon a wall made by a plumbline, with a plumbline in his hand."† Commentators maintain that the word plumbline refers to lead. If so, it is another proof of a very common use to which that metal was then put. Although apparently trifling, this reference shows that lead was plentiful. The objection made to this opinion is, that few lead articles are found in ancient ruins. I do not suppose lead was used but for such coarse work as has been named, and as we use it.

The price said by Pliny to have been paid for lead is about five shillings the avoirdupois pound, which is certainly high, compared with the present price of twopence. One thing we know, they did not work their mines to the same advantage as we now do, as some of their workings have been found still rich in ore which they had laid aside as useless; and the scoria or slag is also

* Wilkinson's Ancient Egypt. † Amos vii. 7.

found to contain much metal.* Although Scripture references to lead are few, still they are sufficient to warrant us in believing that the metal, Lead, was well known, and in constant use in ancient times, and used for similar purposes as now.

* An ancient decree of the senate forbade the working of mines in Italy; but mines of gold, silver, copper, iron, lead, and cinnabar, the property of the State, were worked with great profit in the provinces.—Ramsay's Roman Antiquities.

IRON.

IRON is the most universally diffused of the metals, being present, in some of its combinations, in almost every substance in nature, whether animal, vegetable, or mineral. It is very seldom found in the metallic state; and is extracted for use from its combinations with oxygen, in which combined state it is found in sufficient abundance for all our wants. Its reduction is performed by the same means as described for the oxides of the other metals—namely, mixing with coal or other carbonaceous matters, and subjecting to a heat of sufficient intensity to fuse them. Along with the ore of iron there is generally small quantities of earthy matter, such as clay and silica, which are got rid of by mixing with the ore and coal, any substance, generally lime, which will combine with the earths and fuse into a scoria or slag; this, when melted, floats on the surface of the iron, and is thus separated by being let out of the furnace at a different part from the iron; but in order to appreciate the difficulties in smelting this metal, and its relation to the other metals already treated of, it will be necessary to refer to a few general properties of these different metals.

Tin melts at a temperature of 470° Fahrenheit—lead

melts at a temperature of 620° Fahrenheit. These metals will therefore melt at the heat of a common kitchen fire, of small size, requiring neither bellows nor blast. Copper, silver, and gold melt at a temperature of about from 1800° to 2000° Fahrenheit—a heat which can be obtained without difficulty in a large kitchen fire, with bellows; or, if the fuel is in large quantity, and the proportion of metal small, it may be melted without the use of the bellows. A very little higher temperature than that mentioned here will reduce any of the metals from their ores. Hence, the metallurgical operation required for any of these metals, could be carried on without much mechanical appliance, except large fires; but to melt cast iron requires a heat of about 3000° Fahrenheit, and for malleable iron that temperature produces only a softening. To effect the fusion of cast iron, we must have furnaces of very large dimensions, and powerful steam-engines for blowing the fire, before the heat is sufficiently intense to reduce the ore; and here lies the interest in connection with the inquiry into the metallurgical operations of iron in ancient times, going back even to the infancy of the human race. The smelting and manufacture of iron is surrounded with so many difficulties, and needs so many requirements, and such skill, that we would expect it to have been amongst the last of the metals that were brought into use, and would not, for a long time, become common. Yet, strange, we find it amongst the first metals named in Scripture. Thus: "And Zillah, she also bare Tubal-Cain, an artificer in brass and iron."* In Thomson's

* Gen. iv. 22.

History of Chemistry, the difficulty of iron being known in these early times, is acknowledged, and it is suggested, "That in these early days, it is possible native iron may have existed as well as native gold, silver, and copper; and in this way Tubal-Cain may have become acquainted with its existence and properties."*

This is, however, a begging of the question to get over a difficulty, the difficulty being an unwillingness to allow the inhabitants of the earth then living to possess a certain kind of knowledge. The suggestion is not very happy, seeing there is scarcely an instance of iron being found native, and only in small portions diffused through rocks, which, even allowing it to have been more abundant in the early ages of man's history, the difficulties of getting it free from the matrix would have been about as difficult as reducing it from the ore, except we allow the knowledge of the magnet, by which it could be gathered from the rock after being ground—but this would be an admission equally baseless. If the soil be so destructive to iron as to oxidise and destroy articles made of it in the course of a few centuries, so that all traces of them are lost, the oxide becoming diffused, this same effect would go on with native iron.

A few centuries after the flood, iron ore is referred to in the following language: "Iron is taken out of the earth."† And Moses refers to iron furnaces in a way that shows them to have been in use, and to be well understood by those he was addressing, making the furnace an object for an allegorical figure expressive of intense suffering: "But the Lord hath taken you, and brought

* Thomson's History of Chemistry, vol. i. † Job xxviii. 2.

you forth out of the iron furnace."* The same writer also refers to the ore of iron existing in Palestine, thus: "Out of whose hills thou mayest dig iron and brass."† And that it was a common article of use in different countries, is more evident from its being mentioned amongst articles taken from the Midianites, concerning which, general rules were given for purifying: "The gold, the silver, the brass, the tin, the iron, and the lead, ye shall make go through the fire."‡ And in corroboration of these statements showing the early use of iron, and even of steel, the following is taken from Wilkinson's *Ancient Egypt:*—"Iron and copper mines are found in the Egyptian desert, which were worked in old times; and the monument of Thebes, and even the tombs about Memphis, dating more than 4000 years ago, represent butchers sharpening their knives on a round bar of metal attached to their aprons, which, from its blue colour, can only be steel. And the distinction between the bronze and iron weapons in the tomb of Rameses III., one painted red and the other blue, leaves no doubt of both having been used at the same periods."

These facts harmonise with the engravings on the precious stones and other works referred to in Scripture, which, so far as our knowledge goes, necessitates the use of both iron and steel, as already mentioned. The fact of there being no iron articles found in the ancient ruins of Egypt and Nineveh, is easily accounted for in the rapid destruction of that metal when exposed to air and moisture. The iron instruments of war and art, used by our own forefathers a few centuries ago, that have

* Deut. iv. 20. † Deut. viii. 9. ‡ Num. xxxi. 22.

been subjected to such action, are now, when found, mere fragments, with scarcely a trace of their original shape—which a visit to any of our public museums will verify—so that the absence of similar articles in very ancient ruins is thus easily accounted for. It is true that ordinary history says little or nothing of iron in ancient times—a circumstance often referred to in proof of iron not being known, or, if known, only obtained in very minute quantities. It is well known that those books most valuable and ancient are seldom referred to when this subject is considered; and we have cause to regret that not a few of those who profess their belief in the divine authenticity of the Scriptures, pass over such incidental references with indifference, and, to avoid noticing seeming difficulties, admit certain inferences upon art without much inquiry. In my opinion, numerous incidental references to arts and manufactures, or the products of these, are of very great importance, as illustrations of great truths in history, and also of the existence of arts which, because of impressions that these ages were barbarous, some cannot admit to have existed. If, in Scripture, we find iron articles named, as being used for the ordinary purposes of life, and the same purposes to which it is now used by ourselves, it is much stronger evidence, because positive, that iron was abundant, than any absence of the mention of iron in the meagre history of other nations, or the non-existence of iron in ancient ruins can prove that iron was not known, or only known partially. It is no stretch of fancy, or of reason, to conclude from such references that the means of extracting iron from

its ore was well known, and so easily performed by them, as to be no barrier to its common and every day use. And if for its manufacture we require particular-built furnaces, and strong blasts, they must have had means of producing the same effects; and whether their appliances for this purpose were the same—the furnaces built of brick or stone, or their blast by bellows or engine, or whether they used wood or coal as fuel, or made one ton per day or per week—we know not; the fact, however, is undeniable, that they were in possession of means of overcoming many of the same difficulties that we overcome; and that the advancement we have made is more in the means of facilitating the process, than in any discovery of the reduction. Even the extent of these appliances is made more apparent by referring to the several objects to which iron was applied, as recorded in Scripture.

Of the method practised by the ancients for obtaining the iron from the ore, there is no reference in Scripture; and so far as we comprehend the reference in other ancient writings, there is no evidence to show that the ancients knew cast iron; but they were well acquainted with malleable iron and steel. The method adopted by the Indians is very simple, and of a very ancient date, and probably is the same that was practised by the ancient Egyptians, as well as other nations.

The furnace is built as follows: First a trench is made in the ground about three feet deep, having a sloping side or entrance, and then a furnace of brick or stone is made upon the side of the trench; the bottom of the furnace has an incline into the trench, and holes to let

the slag through the furnace. After a fire is kindled, the ore of iron, which is an oxide, is mixed with charcoal and put into the fire; two bellows made of skins are connected to a clay-pot, which projects from the bottom of the furnace—these are placed upon a plank or planks placed over the trench in front of the fire. A man sits and works the bellows by hand, pressing down one with the right hand, and then the other by the left, which produces a continued stream of wind. In a short time the ore of iron softens, a part of it melts along with the impurities, and forms a slag or scoria, which is taken out by one of the holes or openings of the furnace. The remainder of the iron loses its oxygen by the charcoal, and forms a tough, pasty mass. About twelve hours after, the iron is withdrawn in blocks. The blocks of crude metal are then put into another furnace, and heated to a welding heat; it is then taken out and subjected to beating and hammering. This beating drives out any scoriaceous matters, and the metal toughens and refines. This method, with slight modifications of the shape of the furnace, arising probably from local circumstances, has been in use from the earliest ages, not only for iron, but that compound of it termed steel, which will be apparent from the following interesting account of the manufacture of iron and steel in India, given by Dr Ure:—

"The manner in which iron ore is smelted and converted into wootz, or Indian steel, by the natives at the present day, is probably the very same that was practised by them at the time of the invasion of Alexander; and it is a uniform process from the Himalaya moun-

tains to Cape Comorin. The furnace or bloomery in which the ore is smelted, is from four to five feet high; it is somewhat pear-shaped, being about five feet wide at bottom, and one foot at top. It is built entirely of clay, so that a couple of men may finish its erection in a few hours, and have it ready for use the next day. There is an opening in front about a foot or more in height, which is built up with clay at the commencement, and broken down at the end of each smelting operation. The bellows are usually made of a goat's skin, which has been stripped from the animal without ripping open the part covering the belly. The apertures at the legs are tied up, and a nozzle of bamboo is fastened into the opening formed by the neck. The orifice of the tail is enlarged and distended by two slips of bamboo; these are grasped in the hand, and kept close together in making the stroke for the blast; in the returning stroke, they are separated to admit the air. By working a bellows of this kind with each hand, making alternate strokes, a tolerably uniform blast is produced. The bamboo nozzles of the bellows are inserted into tubes of clay, which pass into the furnace—at the bottom comes off the temporary wall in front. The furnace is filled with charcoal, and a lighted coal being introduced before the nozzles, the mass in the interior is soon kindled. As soon as this is accomplished, a small portion of the ore, previously moistened with water to prevent it from running through the charcoal, but without any flux whatever, is laid on the top of the coals, and covered with charcoal, to fill up the furnace. In this manner ore and fuel are supplied, and the bellows are urged for

three or four hours. When the process is stopped, and the temporary wall in front broken down, the bloom is removed with a pair of tongs from the bottom of the furnace.

"In converting the iron into steel, the natives cut it into pieces to enable it to pack better in the crucible, which is formed of refractory clay, mixed with a large quantity of charred husk of rice. It is seldom charged with more than a pound of iron, which is put in with a proper weight of dried wood, chopped small, and both are covered with one or two green leaves, the proportions being, in general, ten parts of iron to one of wood and leaves. The mouth of the crucible is then stopped with a handful of tempered clay, rammed in very closely to exclude the air. As soon as the clay-plugs of the crucible are dry, from twenty to twenty-four of them are built in the form of an arch in a small blast-furnace; they are kept covered with charcoal, and subjected to heat, urged by a blast, for about two hours and a-half, when the process is considered to be complete. The crucibles being now taken out of the furnace, and allowed to cool, are broken, and the steel is found in the form of a cake, rounded by the bottom of the crucible."* The remnants of some of these hole furnaces or bloomeries still exist in our own country.

These modes of manufacturing iron and steel are, in the opinion of all who have studied the subject, the same as that practised in the earliest ages of the world; and although the processes are simple, and the apparatus rude, still they are very effective, and produce metals of

* Ure's Dictionary of Arts and Manufactures, article Steel.

the best kind. Rude as the whole appears to be, yet, to gain that point, must have been the result of considerable experience. The formation of the bellows—the composition of the crucibles—the charging of the furnaces and crucibles—all tell of experience and observation. Pliny, and several other ancient writers, mention various countries and places which, in their time, produced excellent steel. And the art of hardening iron and steel, by immersion, while red-hot, in cold water, is referred to by Homer. He says, that when Ulysses bored out the eye of Polyphemus with a burning stake, it hissed in the same manner as water when the smith immerses a piece of red-hot iron in order to harden it. The passage is thus translated by Pope:—

> "And as when armourers temper in the ford
> The keen-edged pole-axe, or the shining sword,
> The red-hot metal hisses in the lake—
> Thus, in his eye-ball, hiss'd the plunging stake."

In ages approaching near to the Christian era, amongst the Greeks and other nations the operations in the smelting of iron were performed by slaves. If this was the practice in ancient Egypt, it is not improbable that one of the forms of slavery used to coerce the Israelites, was labouring in the iron furnaces; and when Moses speaks of having delivered them from the iron furnace, there may have been a reality in the reference which would be fully understood by all who had suffered such oppression. Diodorus, writing long after the exodus, represents the labour of the slaves, at the iron furnaces of Greece, as the most intolerable of all tyrannies.

In order to give some idea of the extent of the

manufacturing of iron—in the absence of direct reference—I will mention the several objects iron was applied to, as recorded in the Scriptures and other works. It will be seen that several of these applications are anticipations of modern inventions: "He shall flee from the iron weapon, and the bow of steel shall strike him through."* "That they were graven with an iron pen."† "Canst thou fill his skin with barbed irons? or his head with fish spears?"‡ These lead to important inferences. The steel bow, the harpoon with barb, and fish spear, common instruments of hunting, centuries before Moses wrote, are all significant references: "For only Og, king of Bashan, remained of the remnant of giants; behold, his bedstead was a bedstead of iron."‖ "And all the Canaanites who dwell in the valley have chariots of iron, both they who are of Beth-shean and its towns, and they who are of the valley of Jezreel."§ "And Judah could not drive out the inhabitants of the valley, because they had chariots of iron."¶ Another reference to chariots of iron is here given: "Jabin, king of Canaan, who reigned in Hazor, the captain of whose host was Sisera, who dwelt in Havasheth of the Gentiles. And the children of Israel cried unto the Lord, for he had nine hundred chariots of iron, and twenty years he mightily oppressed the children of Israel."** Even allowing, as some suppose, that these iron chariots rather refer only to chariots with iron weapons, like scythes, stretching out from their sides—which chariots were driven with great force through the ranks of the enemy, mowing them down

* Job xx. 24. † Job xix. 24. ‡ Job xli. 7. ‖ Deut. iii. 11.
§ Josh. xvii. 16. ¶ Judges i. 19. ** Judges iv. 23.

in their course—it does not invalidate the statement that iron was abundant, and used in great quantities by the nations of that early period.

"And the staff of his spear was like a weaver's beam, and his spear's head weighed six hundred shekels of iron;"* "And he brought forth the people that were therein, and put them under saws, and under harrows of iron, and under axes of iron, and made them pass through the brick-kiln;"† "But the man that shall touch them must be fenced with iron, and the staff of a spear;"‡ "And Zedekiah, son of Chenaanah, made him horns of iron;"‖ "And David prepared iron in abundance for the nails for the doors of the gates, and for the joinings;"§ "Whose feet they hurt with fetters: he was laid in iron;"¶ "He hath broken the gates of brass, and cut the bars of iron in sunder;"** "I will break in pieces the gates of brass, and cut in sunder the bars of iron;"†† "The sin of Judah is written with a pen of iron;"‡‡ "I have made thee this day a defenced city, and an iron pillar;"‖‖ "Thou hast broken the yokes of wood, but thou shalt make for them yokes of iron;"§§ "Moreover, take thou unto thee an iron pan, and set it for a wall of iron, and set it between thee and the city;"¶¶ "They drank wine, and praised the gods of gold, and of silver, of brass, of iron, of wood, and of stone;"*** "For three transgressions of Damascus, and for four, I will not turn away the punishment

* 1 Sam. xvii. 7. † 2 Sam. xii. 31. ‡ 2 Sam. xxiii. 7. ‖ 1 Kings xxii. 11.
§ 1 Chron. xxii. 3. ¶ Psa. cv. 18. ** Psa. cvii. 16.
†† Isa. xlv. 2. ‡‡ Jer. xvii. 1. ‖‖ Jer. i. 18. §§ Jer. xxviii. 13.
¶¶ Ezek. iv. 3. *** Dan. v. 4.

thereof, because they have threshed Gilead with threshing instruments of iron."*

That iron was imported and sold in the public markets in early times, is evident from the passage in Ezekiel, before quoted.† Different qualities of iron are also referred to in connection with certain localities, thus: "Shall iron break the northern iron and the steel?"‡ To the north of Judea was situated Chalybia, the inhabitants of which were said by the Greeks to have discovered the tempering of steel. Commentators generally suppose that this passage refers entirely to steel, in all probability made in the manner already described. The mode of working and tempering iron seems to be referred to in the following passage: "The smith with the tongs both worketh in the coals, and fashioneth it with hammers, and worketh it with the strength of his arms."|| Michaelis translates the passage thus: "The smith bends the iron, works it in a fire of coals, and forms it with the hammer; he labours on it with a strong arm." Bright iron is also referred to in Scripture; and that it was nothing else than polished iron is very probable: "Dan also and Javan going to and fro occupied in thy fairs: bright iron, cassia, and calamus, were in thy markets."§ Its possession would appear to constitute wealth, for we read as follows:— "Return with much riches to your tents, and with very much cattle, with silver, and with gold, and with brass, and with iron."¶

Its superior hardness above all other metals is also

* Amos i. 3. † Ezek. xxvii. 12. ‡ Jer. xv. 12. || Isa. xliv. 12.
§ Ezek. xxvii. 19. ¶ Josh. xxii. 8.

often referred to: "And the fourth kingdom shall be strong as iron: for as much as iron breaketh in pieces and subdueth all things: and as iron that breaketh all these, shall it break in pieces and bruise."* The practice of sharpening iron with iron is noticed: "As iron sharpeneth iron: so a man sharpeneth the countenance of his friend."† That iron instruments were used for cutting down trees, is evident from the following passage:—"And he shall cut down the thickets of the forest with iron."‡

Hesiod divides the ages of man into four, namely, golden age, silver age, bronze age, and the iron age—which last was the one he lived in—supposed to be about 944 B.C., a few years after Solomon's death. Although this is no doubt an allegorical comparison, yet it must have a relation to historical facts, and is therefore significant in this inquiry. Homer represents one of his heroes encouraging his men in the following words: "Their flesh is neither stone nor iron, to endure strokes given with the cutting edge of bronze;" rather an anomalous circumstance to use a bronze weapon, when iron is acknowledged to be able to resist its strokes, and to be every way superior; and as Homer flourished in the iron age of Hesiod, one would have expected his hero to have been furnished with iron weapons; while Achilles' sword is stated to have been made of bronze.

Particular attention has been given to all the references in Scripture, because the existence of iron in large quantities in ancient times has been doubted; and the

* Dan. ii. 40. † Prov. xxvii. 17. ‡ Isa. x. 34.

opinion generally maintained, that bronze was used previous to iron, and for all the purposes for which iron was afterwards used. It is also stated by Greek writers, that iron was discovered about the year 1406 B.C.—fifty years after Moses wrote, and many centuries after Job. I am rather inclined to differ from the generality of those who have thought on the subject; and the more it is considered in connection with other circumstances, the more the assertion that bronze was used instead of iron for all purposes, appears incorrect and untenable. The first notice of bronze in the Scriptures, is in connection with iron. And even allowing that Moses, in stating that Tubal-Cain was an instructor of every artificer in iron and brass, was only repeating a common tradition of his day, it will not affect the correctness of the assertion that iron was known as early as bronze. The book of Job has many references to iron, showing that it was used for those purposes which Greek writers say bronze was applied long after. It is difficult to understand how bronze-edged tools alone could be used in the engraving and hewing of stones, etc., such, for example, as engraving the names of the twelve tribes of Israel on the twelve precious stones set in the breastplate, these stones being of the hardest known substances. This is admitted to be difficult to explain by those who have considered the subject; and the conclusion generally come to is—that they did so in their day, and it is more than we can do in ours.

Allowing that no tin mines existed near the locality where the human race first appeared, bronze could not possibly be made until population had advanced, and

trade and commerce established in the locality where tin was found; circumstances that put a bronze age after the Deluge or dispersion of the human race. At the same time, it ought to be remembered that both copper and iron ore were found near to, if not in, the country first inhabited by man; and at the time Job flourished copper ore was smelted; and although this is not stated of iron ore, yet iron and steel are said to have been in use. It therefore follows, as a probability at least, that iron ore was smelted as well as copper ore, and also, that iron and copper were likely to be in use before bronze. When tin was found, and the quality of bronze discovered, we can easily conceive how it would become a favourite alloy, seeing how easily it can be melted and cast into shape, compared with copper and iron. Wilkinson admits some of the difficulties I have mentioned, in alluding to bronze tools for hewing granite—as such tools are supposed to have been used in Egypt for that purpose; and the finding of a bronze chisel in a quarry at Thebes seems to prove the assertion to be correct, that the Egyptians did so; yet, on this chisel being tried, it could not cut stone—the length of the exposure may have changed its properties. This, however, is certain—any account of trials made prove that there is no bronze manufactured now which could stand the hewing of granite. A few experiments made, and published in Aiken's *Arts and Manufactures*, give the following results:—

Copper, ...	88·9
Tin, ...	11·1
	100·0

Produced a good bronze, that took on a fine edge, and could cut ordinary brass easily—

Copper, ...	85·7
Tin, ...	14·3
	100·0

Formed a bronze harder than the above; bears making an edge to make a pen with difficulty; makes good chisels for cutting wood—

Copper, ...	87·5
Tin, ...	12·5
	100·0

Harder than any of the above two, but will not bear much hammering—and is nearly as hard as steel, but very brittle. It is remarked that hammering produces a certain elasticity, and that the second named might do for swords.

It may be asked, Is the fact of finding a bronze chisel in a quarry a sufficient reason for arguing that it, or bronze generally, had been used for hewing stones? and also, why bronze should be used for such a purpose, at a period when steel was in such common use as to be used by the butchers for sharpening their knives? which fact is proved by the paintings on the tombs, etc., as given in Wilkinson's work. Were the knives iron or bronze? About the same time that the chisel is supposed to have been used, the following commands were given: "And there shalt thou build an altar unto the Lord thy God, an altar of stones: thou shalt not lift up any iron tool upon it. Thou shalt build the altar of the Lord thy God of whole stones."* "As

* Deut. x vii. 5, 6.

Moses the servant of the Lord commanded the children of Israel, as it is written in the book of the law of Moses, an altar of whole stones, over which no man hath lift up any iron."*

This prohibition is against hewing or dressing stones for the altar. Now, if bronze tools were used for this purpose, why is iron named, and not bronze? and if bronze was in use at all for hewing, the prohibition was incomplete by naming iron only. As this restriction was given shortly after the Israelites left Egypt, it may apply to the Egyptian practice. It may be, as suggested by Wilkinson, that if the iron or steel was scarcer than bronze, a shield of steel may have been used over the bronze edge. The whole question is interesting, and will no doubt receive further illustration when more extensive investigations have been made by those engaged in excavating the ruins of ancient cities.

Overlaying of iron with tin has been mentioned as an art probably known to the ancients. Pliny mentions the overlaying of copper with tin, as is now done, to protect culinary vessels from poisonous verdigris. No articles made of iron, overlayed with tin, have been found; but this can scarcely be a proof against its being used in ancient times, as tinned iron is very easily destroyed by corrosion. It is now known that iron was covered with bronze, which gave the strength of iron when required, and, at the same time, retained the external beauty of the bronze. Several objects having this overlaying were found in the ruins of ancient Nineveh by Mr Layard, who has the following passage upon this remarkable fact:

* Josh. viii. 31.

"It would appear that the Assyrians were unable to give elegant forms or a pleasing appearance to objects made in iron alone; and that, consequently, they frequently overlayed that metal with bronze, either entirely or partially, by way of ornament." Dr Percy's views on this subject have already been given, (see page 89.)

It may be remarked here that the operation of covering iron with bronze is one of considerable difficulty in our day, and not known to have existed previous to these examples of the ancients being brought to light. And these instances or facts prove that the ancients were well skilled in metallurgical operations, and also verify the truth of the words of Scripture in their many references to iron and other metals. Perhaps, however, some of these references allude to practices now unknown; hence the difficulty often experienced by commentators and others who endeavour to explain them.

CONCLUDING OBSERVATIONS.

SUCH, then, are the results obtained in considering the different metals known to the ancients—so far, at least, as the Scriptures refer to them—and the conclusion arrived at is, that the ancients obtained their metals from the ores by fusion—similar to what is done at the present day—and that we are warranted in believing that practical metallurgy had its orgin in the first ages of the world, and has continued in every age, although generally more extensive in certain localties, or amongst a certain people, than others, and even in certain ages more than in others—but never lost. The methods of obtaining gold and silver, and the purifying of these from other metals—as alluded to in Scripture—clearly indicates that the ancients adopted the same processes that are practised at the present day for the same ends; and although the particular metallurgical operations for extracting the other metals are not so clearly defined, still, considering the difficulties we experience in the performance of such operations, we are forced to admit that they must have experienced the same difficulties; and the question—Did they adopt the same means of overcoming these difficulties? is not so important as the fact that they were overcome, and that

they had the different metals then known in abundance, and as pure as we now have them. Neither have we any idea of the forms of their furnaces or the materials used in their construction; but that they had great facility in constructing such furnaces and melting metals, is evident from the short time taken by Aaron to cast the calf or bull. At least, were artificers in this age placed in similar circumstances as the Hebrews were in the wilderness, and called upon to make or cast such a figure as a calf in metal, they would find it difficult to do the work within the time the Israelites did it; and except they had the necessary moulds and other instruments, this could not be done without the presence of the most skilled artificer. All these the Israelites would also require, and, if they had such things with them—and there is every probability they had—then our position is strengthened in stating that the Hebrews were, many of them, the skilled artificers of Egypt, and in leaving, had carried their tools with them. If they did not do so, their skill is made more prominent in forming all that was required for that work.

Upon the subject of moulds we quote the following from Wilson's *Archæology:* "Among all the varied and primitive relics which have been from time to time discovered, none exceed in interest the stone and bronze moulds in which the earliest tools and weapons of the native metallurgists were formed. They have been found in Scotland, England, Ireland, and in the Channel Islands, exhibiting much diversity of form and various degrees of ingenuity and fitness for the purpose in view, some of which are of bronze, and highly finished. In the

museum of the Society of Antiquaries of Scotland there are casts of a pair of large and very perfect bronze Celt moulds of unusual size and peculiar form.

"But still more interesting are the ruder stone moulds, in some of which we may trace the full efforts of the Aborigines of the stone period, to adapt the materials with which they are familiar to the novel arts of the metallurgist. This is particularly observable in a mould stone preserved in the Belfast Museum. It is polygonal in form, and exhibits upon four of its surfaces indented moulds for axe-heads of the simplest class. In this example there is no reason to believe that any corresponding half was used to complete the mould. The melted metal was simply poured into the indented surface, and left to take shape by its equilibrium on the exposed surface. Weapons formed in this way may frequently be detected, while others, full of air-holes, and roughly granulated on the surface, appear to have been made in the still simpler mould formed by an indentation in sand; others of the stone moulds have consisted of pairs like those of bronze. A very curious example of this description was found a few years since in the isle of Anglesea. It is a cube of hone-stone, nine inches and a-quarter in length, by four inches in breadth at its widest extremity. Each of its four sides are indented for casting different weapons—two varieties of spear, a lance, or arrowhead, and a celt with two loops. Only one stone was found, but another corresponding one is obviously requisite, by means of which four complete moulds would be obtained."

The means adopted for getting an intense heat to melt and cast metals, were similar to ours—by bellows

or blowing. Wilkinson, in his *Ancient Egypt*, has given the figure of a smelting operation. The furnace seems only a heap of fire upon the surface of the earth, and the bellows are two large bags filled with air, upon which a man is standing with a foot upon each bag—the aperture of the bag being connected with a pipe leading into the fire; while the man is seen putting all his weight upon one bag to compress out the air into the fire, he is also seen lifting up his foot, and, at the same time, the upper fold of the other bag, by a string in his hand, by which the bag is being again filled with air. This apparatus is, no doubt, both simple and rude, and if it refers to the ordinary metallurgical operations performed by the nation, one could hardly suppose that castings of any great size could be obtained but with great difficulty; nevertheless, such a simple apparatus may have been used by the Hebrews in the wilderness, both in the construction of the ark, the calf, and the serpent. Looking at the operation as figured, Wilkinson justly remarks, that rude as it may seem, it indicates the knowledge of certain fundamental principles, such as the valve, which had not been before accredited to them—for these bags, when emptied, could not be refilled and preserve their usefulness without a valve. The bellows used by the Indians had no valve, (see page 139.)

As to the quantity and cost of the various metals, there is no data; but it may be stated, that a metal, as well as any other object that has a known intrinsic use, and is required by a community, will rise and fall in value, corresponding to the quantity to be obtained and the cost of production; so that if a pound of iron is required, and it cost the value of the weight of an ounce

of gold to obtain and bring to market, then that would be the relative value of the two metals. This law holds good in all ages and countries; and the fact of iron ore existing in abundance, will not lower the value of the metal if the cost of extracting it from the ore is great. For instance, the metal Aluminium sells just now at about £5 or £6 per ounce, notwithstanding that the ore of that metal, which is common clay, is so abundant. In Scripture, iron is always referred to as an article of comparative low value, and of greater abundance than bronze, as indicated in such a passage as this: "And gave for the service of the house of God of gold five thousand talents and ten thousand drams; of silver, ten thousand talents; of brass, eighteen thousand talents; and one hundred thousand talents of iron."*

Hence, upon the same principles, I infer that the methods of extracting iron were so far simple and easy as to enable it to be sold cheaper than either tin or copper, which appears to favour Dr Percy's view, that they may have overlaid iron with bronze for the purpose of economy—as we find they did, and probably for the same reasons, when neither weight nor strength were required —such as overlaying wood with bronze. We have no evidence as to quantities of iron in use beyond what has been already given in reference to the articles made of iron, yet, if iron was more plentiful and cheaper than bronze—which I think evident from the common things mentioned as being made of it—the few proofs that were given of the enormous quantity of bronze used up in the temple, will give a faint idea of the great quantity of iron also collected at that time, supposing

* 1 Chron. xxix. 27.

the relative quantity given in the above passage to be as 18 bronze to 100 iron. If these relations and conditions keep pace, the abundance of iron, in the time of Alexander the Great, must have been very great, when the bronze statues were so numerous as to induce Pliny to call them the mob of Alexander; and it is related that Mutianus, the Roman consul, found 3000 bronze statues at Athens, the same number at Rhodes, and as many at Olympia and Delphi.

The perfection in the art of casting bronze attained by the Grecians, is amply borne out by the many specimens of such art still existing, and scattered throughout the various museums of Europe—a perfection which artificers of the present day endeavour to imitate—to surpass, is considered impossible. How far we are to look back to the first attainment of the high state of perfection in the metallic arts is not known.

It must not be conceived that because the ancients attained a high position in the arts, and, to a great extent, in what is termed refinement, that they were equally advanced in the true element of civilisation. There seems to be no direct connection between the attainment of intellectual knowledge, or great power of production, and the higher parts of our moral nature. These high attainments were misapplied—their head and hands were cultivated, but not their heart. They were debased in their religion, and, consequently, in all else of their moral life. The Canaanites, under Jabin, applied all their energy and skill in the art of war. Their five hundred chariots of iron were instruments of destruction. The celebrated monster image set up in the plain of Dura, whose height, according to the defini-

tion of a cubit adopted in this work, was 105 feet high, and 10½ feet broad, was a wonderful work of art, but exhibiting a still more wonderful depth of debasement.

It must have been observed by those who have read works on the genuineness or authenticity of the Pentateuch, and other books in the Old Testament, that one argument often used by a certain class of thinkers is, that articles of manufacture are named in these books as being in common use at the time they were written; while, from profane history, it can be shown that materials or substances capable of making such articles were not discovered till long after the reputed author of the sacred books was dead, and, consequently, such books could not have been written by that author, or the account of these articles must have been interpolated by later hands, and thus Scripture history must be considered doubtful. In writing this work, I have been often struck with the evidence that certain arts have been discovered or practised by one people or nation, and lost at their decline, and re-discovered by another people; and probably more than once this discovery and loss has taken place in the history of nations. How soon, for example, were many of the fine arts lost amongst the Hebrews from the time they left the land of Egypt to the time of the building of the temple!

It appears probable that many of the ancient nations besides the Israelites often attained to great perfection in particular arts; but by a change of dynasty, or a series of wars, the arts fell into desuetude, and were forgotten by the artificers dying out, no written record or description being left of the art. Long after this period the same art is again discovered and practised, and the

history of this last discovery being written, it is remembered. As an illustration, Hesiod, Plutarch, and other ancient writers, mention that iron was discovered after the fall of Troy, while we possess a long list of iron articles in common use many centuries before Troy was founded. The book of Job, which is generally believed to have been written many centuries before that period, speaks familiarly of iron. So also do Moses and Joshua, both of whose books were written long before the Grecians date the discovery of iron. It is more than probable that, in such instances, the individuals or parties named as discoverers were merely the introducers of the art, not the original discoverers.

Another instance of the same kind, but still more untenable, is a statement made in the Appendix to Mr Layard's *Nineveh*:—

"Previous to Homer, no trace of casting has been discovered, while it is expressly stated that this art, as well as that of soldering, were inventions a little subsequent to his time." "The discovery of the first is attributed to Rhoecus and Theodorus, both Saurians." —*Pliny.* "The invention of the latter—that of soldering—is attributed to Glaucus of Chios."—*Herd.* Another invention of his was the alternate hardening and softening of iron. In respect to this invention reference has been already made—even from Homer —centuries before Glaucus lived. As to casting, the references are numerous, long prior to Rhoecus. What he discovered or introduced that has identified his name with casting, we know not. Casting in core is said to to have been discovered in Greece long after Hiram and Solomon flourished; still, if the pillars in the temple

were hollow—which I think was the case—they must have been cast with a core. The casting of bronze with a centre of iron, as noticed by Dr Percy, (see page 89,) could not but suggest the using a core of other material that was movable afterwards.

The art of soldering may have been discovered or introduced into Greece by Rhoecus; still, it was known to other nations long before his time. It is mentioned by Isaiah, in a passage previously quoted; and Wilkinson found evidence of it having been practised in ancient Egypt; and articles soldered about the time of the Pharaohs are still existing.

The glazing of pottery with oxide of lead, is considered, and truly so, a discovery of modern times; but it was also known in the early days of Egypt, and probably, also, to other nations in ancient times.

Plating copper with silver, by fusing their two surfaces together, is an invention going back only about 160 years in our own country; yet we have seen that the ancient Peruvians practised the same art, and remnants of it are still found in their ruins; and probably other nations knew the same art.

Marking ink, made with silver solution, is another discovery of modern days; and it is found by analyses of the writings on linen, over the mummies, to have been used by the ancient Egyptians.

These are a few instances out of a great many mentioned in history; indeed, I remember passing through the antiquity department of the British Museum a few years ago, when a gentleman present, pointing to a form of clasp amongst the Egyptian articles, stated, that recently a mechanic in England had regis-

tered the same clasp as a new invention — and no doubt it was to the inventor. How disingenuous and illogical, then, must it be to found an argument against a valuable historical work upon such grounds? Such things prove that the advancement of society, of the human race, is like the waves of the sea upon the beach during a tidal flow. One wave comes, and again recedes nearly as far as it had come; another follows, and repeats the same rise and fall, still each gains a little, and their gainings, added together, form the full tide, which may also be described as a series of curve or wave lines, the advancement not being one continuous ascent, but a series of gains and losses. But the tide of progress flows on. One wave may take a little longer to reach its altitude, and may again rapidly sink; but a flow cometh, gathering in its course all that is good and valuable, till the tide of human civilisation is at its full. How observant of all this is the preacher! "The thing that hath been, it is that which shall be; and that which is done is that which shall be done. Is there anything whereof it may be said, See, this is new? it hath been already of old time, which was before us."* Let us be satisfied with the fact that the great work of progress is going on, and a time coming when art and science will go hand in hand for the attainment of one glorious object—the universal good of mankind — when there shall be nothing to hurt or destroy in all the earth.

* Eccles. i. 9.

APPENDIX.

EXHIBITIONS OF ART. — The year 1851 was made memorable in this country, by the inauguration of what was termed a new thing—an exhibition of the industry of all nations—the product of art and manufacture. The motives for such an exhibition were to stimulate improvement, and excite friendly rivalry in all the peaceful arts of life—proclaiming, in the most unmistakable language, the elevating tendency of human progress.

Exhibitions of manufactures are old, but that of 1851 had characteristics peculiar to itself; for comparison, I will refer to one recorded in ancient times—one which lasted the same time as our own—six months; but how different the motives!—"In those days, when the king Ahasuerus sat on the throne of his kingdom, which was in Shushan the palace, in the third year of his reign, he made a feast unto all his princes and his servants; the power of Persia and Media, the nobles and princes of the provinces, being before him: when he shewed the riches of his glorious kingdom and the honour of his excellent majesty many days, even an hundred and fourscore days. And when these days were expired, the king made a feast unto all the people that were pre-

sent in Shushan the palace, both unto great and small, seven days, in the court of the garden of the king's palace; where were white, green, and blue, hangings, fastened with cords of fine linen and purple to silver rings and pillars of marble: the beds were of gold and silver, upon a pavement of red, and blue, and white, and black, marble. And they gave them drink in vessels of gold, (the vessels being diverse one from another,) and royal wine in abundance, according to the state of the king."* This must have been a magnificent exhibition. The number attending this feast is not ascertainable; but if the princes and nobles of the provinces, which were 127 in number, and all the officers and great men of Persia and Media, and servants of the palace, great and small, were there, it must have formed an immense company. Now, every one drank out of a golden cup of a different pattern, giving an idea of profusion in art, that we can form but a very limited perception; and also indicates that variety of pattern was an object sought after—a fashion favouring and fostering the development of art and design, worthy of being emulated in the present day.

AMBER.—This word occurs several times in Scripture, as, "Then I beheld, and lo a likeness as the appearance of fire: from the appearance of his loins even downward, fire; and from his loins even upward, as the appearance of brightness, as the colour of amber."† The connection of amber with fire is considered not at all happy, as that substance loses all polish and brightness by heat, and as

* Esther i. 2-7. † Ezek. viii. 2.

the word amber refers more to the appearance than the object. It is supposed by scholars, that it rather refers to a figure standing in flame, with vesture of bright burnished gold or alloy, similar to the famed alloy referred to in Nehemiah, of which the cups were made, said to be precious as gold.

ANTIMONY.—I do not suppose that this metal was known to the ancients as a metal, but probably some of its compounds. Painting the eyes black was considered a mark of beauty with the women, and was in common practice from a very early date. Thus: "And when Jehu was come to Jezreel, Jezebel heard of it; and she painted her face, and tired her head, and looked out at a window."* "And furthermore, that ye have sent for men to come from far, unto whom a messenger was sent; and, lo, they came: for whom thou didst wash thyself, paintedst thy eyes, and deckedst thyself with ornaments."† The word translated "in paint," is said by commentators to be "stibium," the Latin name of antimony. In the margin of the Bible, the substance said to be used was a sort of black ead or plumbago. It has been rendered, "Thou didst paint round thine eyes with stibium," or lead ore, as others render it. Now, lead ore has no connection with plumbago, nor with stibium, further than when in a fine powder they soil the skin; the lead ore least, plumbago next, and the sulphuret of antimony (stibium) most. I think the latter was the substance used, especially by the wealthier women. It is probable that ores of metals may have

* 2 Kings ix. 30. † Ezek. xxiii. 40.

been used, and their true nature not known. Antimony is a difficult metal to reduce from its ore; and being volatile at a high heat, would be very apt to escape the notice of a metallurgist for a long time.

ZINC.—This metal is generally supposed not to have been known to the ancients. Its alloy with copper, or brass, is said to have been discovered in the 13th century. Probably its distinctive features, and the method of making it from the different materials, may have been found out at that period. But there is no doubt but the alloy was known in Pliny's time. Its oxide was known and used as medicine in his day, and was obtained from the furnaces in the island of Cyprus —a famed locality for copper ore—and from which the name copper has been derived; calamine or carbonate of zinc is repeatedly mentioned as having been found in Cyprus. Now, brass is easily formed by fusing together such ores of zinc with copper ore, and might be used by the ancients long before the metal zinc was discovered. As it is also a volatile metal, it might make the discovery of its true character longer of being known. That brass was known within the ancient period is proved by Mr J. A. Phillips, who gives the following analyses of a brass of Cassio family, B.C. 20:—

Copper, ...	82·26
Zinc, ...	17·31
Iron, ...	·35
	99·92

Large Brass of Nevo, A.D. 60—

Copper,	81·07
Zinc,	17·18
Tin,	1·05
	99·30

Faustina Tin, A.D. 165—

Copper,	79·14
Tin,	4·97
Lead,	9·18
Zinc,	6·27
Iron,	23
	99·69

These show that the alloy brass was known to the ancients; but no fixed quantity of either metal was used, but probably a mixture of zinc ores with metallic copper, or with copper ores.

SHEET SILVER, called plates, is thus described:—"Silver spread into plates is brought from Tarshish, and gold from Uphaz, the work of the workman, and of the hands of the founder: blue and purple is their clothing: they are all the work of cunning men."* Had they rolling mills in these days, or were the sheets beat out by the hammer? I think it was the work of the hammer, and the process is referred to as being in existence in an earlier age; both for forming plates of gold and silver, gold and silver were beat out thin, and cut into threads for sewing or weaving, as referred to in the construction of the ark; and Wilkinson states, that gold

* Jer. x. 9.

was beat out in leaf, and consequently into plates, in ancient Egypt.

TIN.—The oxide of tin was known and used to make glazes for pottery-ware. The oxide of tin is extensively used in our own day, and has been for centuries, for the purposes of dyeing; were the colours named in Scripture dyed now, they would require tin to fix them. There is no known reference to this application of tin in ancient times; but there is no improbability in their using this substance in their dyeing processes. It is well known they were expert dyers, and whatever methods they used, they produced colours, which, for brilliance and permanence, cannot now be surpassed.

MARKING INK.—Upon the knowledge of dissolving silver, and using it as a marking ink, I quote from the Philosophical Magazine the following interesting account, given to that journal by Mr W. Herapath of Bristol:—"While engaged in unrolling a mummy at the Bristol Philosophical Institution lately, I elicited a few chemical facts, which probably might be interesting to some of your readers. On three of the bandages were hieroglyphical characters of a dark colour, as well defined as if written with a modern pen; where the marking fluid had flowed more copiously than the characters required, the texture of the cloth had become decomposed, and small holes had resulted. I have no doubt that the bandages were genuine, and had not been disturbed or unfolded. The colour of the marks were so similar to those of the pre-

sent 'marking ink,' that I was induced to try if they were produced by silver. With the blow-pipe I immediately obtained a button of that metal; the fibre of the linen I proved, by the microscope and by chemical reagents, to be linen; it is therefore certain that the ancient Egyptians were acquainted with the means of dissolving silver, and of applying it as a permanent ink; but what was their solvent? I know of none that would act on the metal and decompose flax fibre but nitric acid, which, we have been told, was unknown until discovered by the alchemists in the thirteenth century, which was about 2200 years after the date of this mummy, according as its superscription was read."

Glass.—Glass, according to Pliny (Hist. Nat. xxxvi. 26), was discovered by what is termed accident. Some merchants kindled a fire on that part of the coast of Phœnicia which lies near Ptolemais, between the foot of Carmel and Tyre, at a spot where the river Belus casts the fine sand which it brings down; but as they were without the usual means of suspending their cooking vessels, they employed for that purpose bags of nitre—their vessel being laden with that substance: the fire fusing the nitre and the sand, produced glass. The Sidonians, in whose vicinity the discovery was made, took it up, and having, in process of time, carried the art to a high degree of excellence, gained thereby both wealth and fame. Other nations became their pupils; the Romans, especially, attained very great skill in the art of fusing, blowing, and colouring glass.

Even glass mirrors were invented by the Sidonians—

etiam specula excogitaverant. This account of Pliny is in substance corroborated by Strabo (xvi. 15), and by Josephus (*De Bell. Ind.* ii. 10, 2.). Yet, notwithstanding this explicit statement, it was long denied that the ancients were acquainted with glass, properly so called; nor did the denial entirely disappear even when the city of Pompeii proved it to be without foundation. Our knowledge of Ancient Egypt has, however, set the matter at rest—showing, at the same time, how careful individuals ought to be in setting up mere abstract reasonings in opposition to the direct testimony of history. Wilkinson, in his *Ancient Egyptians* (iii. 88, 89), has adduced the fullest evidence proving that glass was known to, and made by, that ingenious people at a very early period of their national existence. Upward of 3,500 years ago, in the reign of the first Osirtasen, they appear to have practised the art of blowing glass. The process is represented in the paintings of Beni Hassan, executed in the reign of that monarch. In the same age images of glazed pottery were common. Ornaments of glass were made by them about 1500 years B.C., for a bead of that date has been found, of the same specific gravity as that of our own crown glass. Many glass bottles, etc., have been met with in the tombs, some of very remote antiquity. Glass vases were used for holding wine as early as the Exodus. Such was the skill of the Egyptians in the manufacturing of this article, that they successfully counterfeited the amethyst and other precious stones. Winckelmann is of opinion, that glass was employed more frequently in ancient times than in modern. It

was sometimes used by the Egyptians even for coffins. They also employed it, not only for drinking utensils and ornaments of the person, but for Mosaic work—the figures of deities and sacred emblems, attaining to exquisite workmanship, and a surprising brilliancy of colour. The art, too, of cutting glass was known to them at the most remote periods; but the mirrors found in Egypt are made of mixed metal, chiefly copper. It would be justifiable to suppose, that the Hebrews brought glass, and a knowledge how to manufacture it, with them out of Egypt, were not the evidence of history so explicit, proving that it was actually discovered and wrought at their own doors. Whether it was used by them for mirrors, is another question. That glass, however, was known to the Hebrews, appears beyond a doubt. "The gold and the crystal cannot equal it: and the exchange of it shall not be for jewels of fine gold."* It is the general opinion of scholars, that the word translated crystal in this passage, refers to glass. Crystal, in the modern acceptation of the term, has oxide of lead in its composition.

* Job xxviii. 17.

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GLASGOW:
THOMAS MURRAY AND SON, PRINTERS,
18 Dunlop Street.