Part I*: Technology: The Contribution of Non-Indo-Europeans*

Chapter IV

The Achievements of China

Finally, we come to the great contribution made by China. If we should ask today what three things above all have contributed to or are contributing to our present conquest of the earth, we might possibly agree that printed matter, a convenient medium of exchange of some kind (i.e., paper currency), and powered propulsion are fundamental. All of these -- and of course hundreds besides -- we have derived from China, though often indirectly via the Arab world.

For our wheeled vehicles we initially used draft animals domesticated in the Middle East, but because of harnessing methods, these draft animals could not pull nearly as much as they now do, thanks to the development in China of far more effective systems of harness. But we have of course long since passed out of the draft-horse age into the jet propulsion era. The motive power for such high-speed engines was likewise inspired by the Chinese. In the air, China and the Far East anticipated us in virtually every form of airborne vehicle or device, including of course rockets, but also kites, gliders, balloons, parachutes, weather forecasting, and even the helicopter principle in the form of toys.

Because of the extraordinary developments of Chinese technologists, it is not uncommon to see references to their "science." As we shall try to show this is perhaps an error, even though some of the greatest authorities do it. In reviewing Needham's *magnum opus* on the *Science and Civilization of China,* the Editor of *Discovery* says:[145]

> We are forced to realize that the old question as to why Science failed to develop in China must be replaced by the much more cautious one, "Since the Chinese people have shown ability to observe and invent surpassing that of the West until comparatively recent times, what factors in environment and thought carried them so far and yet prevented the development of the full scientific method?"

145. Under the title "Science and Civilization in China," in the section "The Progress of Science," *Discovery,* Nov., 1957, p.458.

With all due respect to both Needham and the Editor of *Discovery,* I think there is a serious danger here of supposing that Science is merely an extension of Technology, a kind of natural adult stage. I would rather take the view held by James Conant that Science is not merely an extension of Technology, any more than infinity is merely a very very large number; it is in a different category. One should not speak of a 'full scientific method,' any more than one should strictly speak, conversely, of something only being 'half-alive.'

But of their engineering achievements and mechanical and technical skill there is not the slightest doubt. It is all the more remarkable that they did not step over the boundary into the kind of Industrial Revolution which resulted from the development of Science in Europe. Certainly there is no evidence that either they, or any of the other highly developed civilizations we have been discussing, were ever on the verge of doing so. As Herbert Butterfield put it in his *Origins of Modern Science*;[146]

> There does not seem to be any sign that the ancient world before its heritage had been dispersed was moving towards anything like a scientific revolution.

The question of why China stopped short where she did, is explored at great length by Needham: his knowledge of Chinese culture should surely entitle him to speak of their having achieved a measure of scientific knowledge, if he feels it is justified to do so. And this he does. To challenge such an authority must appear as little more than impudence on the part of anyone whose knowledge is so completely derived from secondary sources. Yet even Needham himself makes admissions now and then which are tantamount to saying that he is using the word *Science* to mean merely a highly developed Technology, and nothing more. The Chinese, as he makes quite clear, were never impractical dreamers or people likely to waste time asking questions whose answers did not seem to be of immediate practical value. Yet this is an essential attitude for the scientific mind.

In reviewing Needham's work, Robert Multhauf indicates that the conclusion to be drawn from the two volumes published thus far, is that Chinese Technology participated little and probably contributed little immediately to the development of scientific thought.[147] In fact, Needham himself asserts that the Chinese worldview depended on a totally different kind of thought pattern from that in the West. What he could

146. Butterfield, Herbert, *The Origins of Modern Science*, Bell, London, 1949, p.163.
147. Multhauf, Robert, Book review, *Science,* vol.124, Oct., 5, 1956, p.631.

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have mentioned, perhaps, is that it is not only unlike that of Western Man, but it is exceedingly *like* that developed by almost all other cultures which are non-Indo-European. In a subsequent chapter this will be considered carefully. It is of fundamental importance and to my mind accounts for the absence of Science not only in China but in all other cases.

It is interesting to find that a Chinese man writing a few years ago on this very point, titled his Paper, "Why China has no Science." In this, the author, Tu-Lan Fung, makes it clear that a feeling for the essential personal-ness of Nature is what discouraged experiment: plus a conviction that the definition of what is 'righteous' is what is 'useful' in the immediate sense -- leading to considerable distrust of activities of a purely intellectual or abstract character, and a feeling of positive distaste for experimenting with Nature. Scientific research, in the proper sense, was an im-pure waste of time that almost amounted to sacrilege! As he put it, "to speak of things in abstract and general terms is always dangerous."[148]

Ancient China's technology

But meanwhile in this chapter, we shall review briefly their Technology. That we obtained from China -- silk, porcelain, explosives, paper, printing with moveable type, paper money, the magnetic compass, and mechanical water clocks -- is so well known that the facts need little or no elaboration. That they anticipated us in the use of gas for cooking and heating, cast iron, flame weapons in warfare, and, as has been stated above, the initial conquest of the air is possibly less well known. In addition to this they initiated the use of fingerprinting for identification purposes, chain pumps, the crossbow and a repeating bow with 12 shots per loading, gimbal suspension systems, the draw loom, the rotary fan and a winnnowing machine, piston bellows, wheelbarrows, stirrups, a greatly improved harness for draft animals that enabled them to pull almost twice as heavy a load, deep drilling methods, and much more is even less commonly known.

Marco Polo gives us an extensive account of the use of paper money.[149] He say it was issued in various denominations, stamped authoritatively by the Governor of the mint, and circulated as the only form of valid currency over a very wide geographical area. The bills, he says, were quite remarkably strong and did not tear easily: any which had been torn, however, or had suffered defacement, were recalled to the mint and replaced. Strikingly reflecting our own bills of a few years ago, they contained a promise that they would be redeemed for certain fixed quantities of either precious stones or precious metals upon request! Foreign merchants could

148. Fung, Tu-Lan, "Why China has no Science, *International Journal of Ethics,* 1922, p.237-263.
149. Polo, Marco, *The Travels of Marco Polo, New* York, Library Publications, (undated), Chapter 24, p..37- 140.

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not sell their jewels or precious metals on the open market, but were required to turn them in at the Mint, where they received a good recompense in paper money.

Consider how great such an innovation really was. As Marco Polo says, a man who wished to move could turn in hundreds of pounds (by weight) of valuable goods in personal property, and walk away with a pocketful of money so light as to be hardly noticeable with which in some other part of the Empire he could recover his hundreds of pounds of goods. Everywhere else in the world men were loaded down with the weight of their possessions which often took such a form as to be virtually worthless once the owner left his own locality. What such a scheme did for trade and commerce is incalculable. What paper money does for us today whether in notes or cheques, is virtually to keep our civilization running. Maybe, we would have come to it anyway in time. Certainly we did not initiate the idea. It originated in the 13th century with the Great Khan.

It was, as Needham points out, often many centuries before such inventions reached the West from China. And he also notes that China received from the West very little in return: actually, only four items are listed -- the screw principle, a force pump for liquids, the crankshaft, and clockwork powered by a spring.[150] Of these in turn, only the screw principle and an alternative form of it (the windmill) seem actually to be to the credit of Indo-Europeans, possibly the Greeks for the screw and the Persians for the windmill. There is evidence that even the screw was obtained from Egypt. Needham points out that the art of drilling deep wells or bore-holes as used today in exploiting oil reserves is specifically of Chinese origin.[151] He also mentions that the use of graticules on maps to simplify the specifying and location of places, is probably of Chinese origin, although Ptolemy also employed this method.[152] For almost all Needham's illustrations, one thing can be said, to use his own words:[153]

> Firm evidence for their use in China antedates and sometimes long antedates, the best evidence for their appearance in any other part of the world. . . .

150. Needham J.M., *Science and Civilization in China,* Cambridge University Press, vol.1, p.241. But there is some question about the Screw Principle, Archimedes may have 'borrowed' it from Egypt.
151. Needham, J.M., i*bid.*, vol.1, p.244.
152. Needham, J.M., *ibid.,* vol.1, p.245
153. Needham, J.M., *ibid.,* vol.1, p.241.

He then quotes Toynbee as having said:

> However far it may or may not be possible to trace back our Western mechanical trend towards the origins of our Western history, there is no doubt that a mechanical penchant is as characteristic of the Western civilization as an aesthetic penchant was of the Hellenic. . . .

Of this observation, Needham says, "It is to be feared that all such valuations are built on insecure foundations." The fact is, we simply do not have any such penchant if we judge our 'racial' character by looking at our achievements prior to the time we began to borrow from non-Indo-Europeans. Since that time, racial mixture has taken place on such a scale, and with it of course 'cultural' mixture also, that it is difficult to say for certain who is and who is not Indo-European in many cases. About all we can do is to attempt to gain a certain measure of objectivity in this regard by looking more carefully at the actual achievement involved in many borrowed elements of our civilization which we now think simple and obvious, merely because we have become so used to them.

Take as an example, the preparation of silk. Sarton says of this:[154]

> Consider what the invention implied -- the domestication of an insect, the 'education' of silkworms, the cultivation of the white mulberry, the whole of sericulture!

But -- which is more -- it involved the recognition of the *possibilities* of the material in the first place. Spider web is one of the strongest known natural filament, but it does not seem that anyone ever thought of cultivating spider web for this purpose. The idea of such a possibility is not enough. It requires considerable energy to turn it into a working industry, and although it seems highly improbable that it was done in a single step, somebody must have been alive to the practical advantages of making the effort -- and have demonstrated it could be done. But then it seems, having developed the 'industry' until it was producing results, there it was left . . . with virtually no effort to extend it or improve the technique or seek for substitute insects or even attempt to make a

154. Sarton, George**,** *A History of Science,* Harvard University Press, 1952, p.5, footnote 4.

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synthetic material using the same kind of substance produced by other means. This is the kind of thing we are good at: but we always seem to need the initial stimulation from somewhere else.

Warfare and the conquest of the air

Needham also draws attention to the fact that the Chinese have excelled in the art of war, inventing new weapons and new methods of attack or defence. The repeating or magazine' crossbow, of which an example of the mechanism is to be found in the Royal Ontario Museum, is surely the world's first machine gun.[155] To their credit (?) must also be given the invention of flame weapons and smoke bombs. Although the former appeared in the Mediterranean area first from North Africa, being used there against the Romans, there is no doubt that the Arabs derived them from the Chinese, for they called them "Darts of China." In a classified document on Chemical Warfare published some years ago in the United States, Harold Lamb had this to say:[156]

> A search through Oriental annals reveals other ancestors of present European weapons. But it is a little surprising to find the modern hand grenade, flame-thrower, and cannon in use in Asia centuries ago.
>
> In Roman days vases filled with a fire compound were employed by the Persians at the Siege of Petra. This compound was sulphur, asphalt, and naphtha; and the vases were cast by mangonels (a kind of giant catapult). The flames which sprang up when the vessel broke could not be extinguished. This was the origin of the much talked about Greek fire, which they, having borrowed it from the Arabs . . . were surprised to find would continue to burn on water, a fact which mystified the early Crusaders.
>
> Haram al-Raschid used a sulphur-naphtha compound at the siege of Heraclea. . . . At the siege of Acre, a Damascus engineer destroyed the wooden towers of the Crusaders by casting against them light clay vessels of the fluid until everything was well saturated. Then a flaming ball was thrown out and, as we read in one old Chronicle, "all was destroyed by flame, man, weapons, and all." During the 13th century flame weapons were highly developed by the Arabs. They had hand grenades -- small glass or clay jars that ignited when they broke; and a curious fire-mace, that was to be broken over the head of a foe, its owner keeping well to windward!
>
> Flame throwers appeared in the form of portable tubes that could burn a man to

ash at 30 feet [*We still cannot do much better - or worse - with modern weapons! ACC]* Some of the names of these flame weapons, such as "The Chinese Flower" and so on, only indicate that they had their origin in that country. In fact we find the Chinese of the 13th century very familiar with destructive fire. They had *the pao* that belched flaming power, and the *fie-ho-tsing,* the "spear of fire that flies."

155. Repeating Bow: this is described in the *Bulletin of the Royal Ontario Museum of Archaeology*, No.10, May, 1931, p.11, under the title *Crossbow*.
156. Lamb, Harold, "Flame Weapons," *Chemical Warfare Magazine,* Edgewood, (U.S.), Dec., 1927, p.237.

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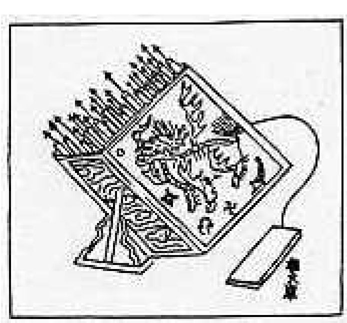
It seems then that the Arabs borrowed much from the Far East -- paint brushes (but with the original pig bristles replaced by camel hair -- for religious reasons), paper manufacture, block printing, silk, alchemy, and of course such weapons of war as the above in addition to explosives. They were great carriers but apparently somewhat uninventive except possibly during one short period of their history. Further reference to this point will be made in the next chapter.

Another document prepared by the Office of the Chief of the Chemical Warfare Service (Washington, 1939) opens with these words:[157]

> Ghengis Khan, famous ruler of the Mongols and of China, used chemicals in the form of huge balls of pitch and sulphur shot over the walls of besieged towns to produce a combination of screening smoke, choking sulphur fumes, and incendiary effects as a standard routine of attack.

Even 'irritating' gases were used by the Arabs against the Roman Legions in North Africa as early as 220 A.D. According to Captain A. Maude, the secret of this weapon was learned by the Romans finally by the capture of a Prince of Mauritania named Juball, subsequently married to Selene, the daughter of Cleopatra.[158]

The Chinese, curiously enough did not make much use of their explosives in warfare by developing cannon until the idea was suggested to them by Europeans! But they did make rocket arrows, and their launching devices were certainly the sires of modern multiple rocket launchers. Some illustrations of these, from a Chinese manuscript, are given in Fig. 22*,* and in Fig. 23 is a single rocket weapon that might well deter anyone! They also developed 'psychological' weapons using large arrows with whistling or 'screaming' heads on them that were guaranteed to stampede horses. Some of their bows were so beautifully designed that, as Klopsteg has shown, they could actually shoot up to half a mile with them.[159]



The Chinese may have used rockets as early as 1232. Here incendiary rocket arrows are launched from baskets.

Launcher built by the Chinese had a capacity of 100 rocket arrows. It could be tilted to alter its range.

Portable launcher had a capacity of 40 rocket arrows. These rockets had a range of some 400 feet.

Fig. 22

157. "The Story of Chemical Warfare" (no author stated), Jan., 1939, p.1.
158. Maude, A., "Ancient Chemical Warfare," *Journal of Royal Army Medical Corps,* vol.62, 1934, p.141.
159. Klopsteg, Paul E., *Turkish Archery and the Composite Bow*, privately published in Toronto, 2nd. edition, 1947.

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Fig. 23 A Chinese rocket weapon.

Their gunpowder burned rather slowly and unevenly. Hence it was not too effective in cannon. But this did not deter them. They made *use* of the fact. Practically speaking, they arranged the cannon's barrel so that it was free to move and then fastened the charge in it so that it stayed with the weapon, thus they had a jet propelled rocket. They then made the tube out of tightly wound paper to save weight, and put a point on it for better flight. But they soon found that because of the uneven burning of the propellant the rocket's flight was somewhat erratic. This they overcame by putting a trailing stick on it to steady it. At first this stick had feathers, but they found that the feathers were simply burned off. It made no difference, for these feathers proved unnecessary. What they did discover was that regardless of the size of the rocket, it had the best balanced flight when the stock was seven times as long as the rocket head. This is still found to be so.[160]

Willey Ley says that the

Arabs learned of these weapons from the Chinese and thus called them "Alsichem alkhatai" or Chinese Arrows.[161] The French Sinologist, Stanislas Julien, has found references to these rockets in China as early as 1232 A.D.

In metallurgy (and in alchemy), the Chinese were far ahead of the West very early in their history. R. J. Forbes, a foremost authority on metallurgy in antiquity, tells us that they were making cast iron stoves by 150 B.C. at least.[162] A picture of one such stove is given for interest's sake, though the original source of the illustration cannot be vouched for. It was used by the Borg-Warner Corporation in an advertisement in a Technical paper (Fig.24).

Fig. 24 An illustration of the earliest known Cast Iron Stove from China as published in an advertisement by the Borg-Warner Corporation, in the Saturday Evening Post, of Sept. 8, 1951.

Another metallurgical journal gives a picture of a huge single cast iron statue which is believed to have been set up in 953 A.D. This is held to be one of the largest single iron castings ever made. It is shown in Fig.25

As a matter of interest, it is sometimes pointed out that the Hittites (possibly a non-Indo-European people with an Indo-European aristocracy) who disappeared from History so completely that their very existence was once doubted, are referred to in cuneiform documents as the Khittai, and sometimes as the Khattai. C. R. Conder suggested that they disappeared because when their Kingdom came to an end, the people packed up and travelled East where they left their name associated with China and the Far East in the form 'Cathay'.[163]

160. Coggins, Jack, and Fletcher Pratt, *Rockets, Jets, Guided Missiles and Space Ships,* New York, Random House, 1951, p.4, with foreword by Willey Ley.
161. Ley, Willey, "Rockets," *Scientific American,* Mar., 1949, p.31.
162. Forbes, R.J., *Metallurgy in Antiquity*, Leiden, Netherlands, Brill, 1950, p.442.
163. Conder, C.R., "The Canaanites" " *Transactions of the Victoria Institute,* vol.24, 1890, p.51.

The Arabs term Chinese

Arrows as Alkhatai, as we have seen. Forbes holds that the Hittites discovered cast iron even before the Chinese did. If this is true, it would suggest that this is possibly where the latter obtained their knowledge of it.

In the conquest of the air, China played a very prior part. Francis R. Miller states that:[164]

> China enters first claim to the invention of the balloon -- centuries before Europe knew it. The Chinese further claim to have had a system of signals by which different toned trumpets sounded from the top of high hills and gave notice of impending changes of wind and weather, for use by navigators of dirigible balloons.

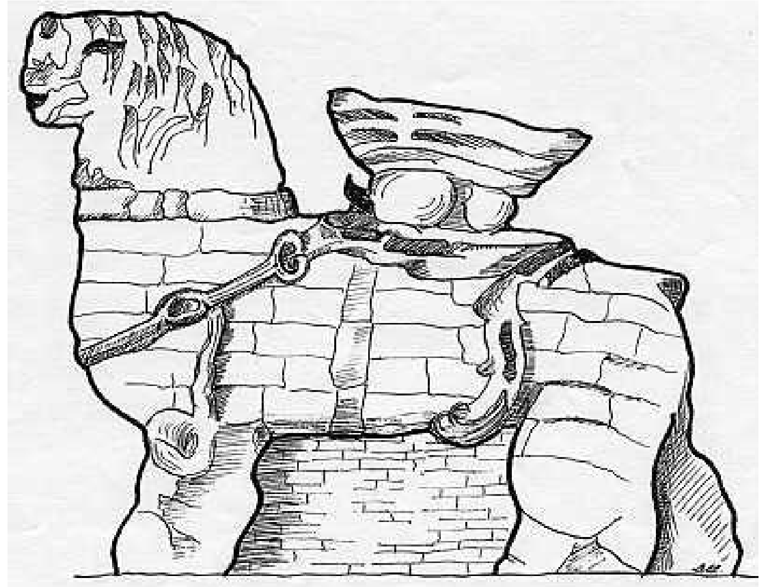

Fig. 25 Cast probably in 953 A.D., this may well be the largest single cast iron figure in the world. It stands in the yard of the Kai-Yuam Monastery in Ts'ang-chow. It is approximately 20 feet high.

Miller gives an illustration from an official Chinese document of a large dirigible said to have been used at the coronation of the Emperor Fo-Kien, in 1306. It was large enough to carry 9 individual gondolas which were lowered to the ground with pulley systems.

In another place Miller reports that:[165]

> A contemporary of Confucius (c. 550 B.C.) named Lu Pan, who was known as "the mechanician of Lu,"is said to have made a glider in the form of a magpie from wood and bamboo which he caused to fly.

Miller also states that kites, as precursors of airplanes, first appeared in Chinese annals at a very early date. Chinese scholars who kept records frequently refer to them. The earliest kites were used for military signalling, first recorded in warfare in the time of Han Sin, who died in 198 B.C., one of the Three Heroes who assisted in founding the Han Dynasty. General Han Sin, plotting to tunnel into Wei-yang palace, flew a kite to measure the distance to it.[166]

According to Needham:[167]

De Ia Loubere saw the parachute used by acrobats in Siam around 1688, and his description was read a century later by Lenormant, who then made some successful experiments and introduced the device to Montgolfier. This is not to deny that the idea of the parachute had been proposed in Europe at the time of the Renaissance, but there are Asian references to it much earlier still.

164. Miller, Francis T., *The World in the Air,* New York, Putnam's, 1930, vol.1, p.99.
165. Miller, Francis T., *ibid, p.*56.
166. Miller, Francis T., *ibid, p.*73.
167. Needham, J., *Science and Civilization in China,* Cambridge University Press, 1954, vol.1, p.231.

More invention 'firsts'

The first suspension bridges with iron chains were constructed in China at least 10 centuries or more before they were known and built in Europe.[168]

The story of printing and of paper manufacture is so well known as to need little consideration here. It came to Europe first with the old camel silk trains as a finished product -- its secret of manufacture jealously guarded. Not until an Arab armed victory over the Chinese armies near Samarkand in 751 A.D. did paper settle in the West as an industry, set up by captured Chinese paper makers. Its use soon spread all over Europe.

The development of printing depended upon the manufacture of suitable ink. We have already mentioned the use of carbon black to strengthen rubber. This material was first made by the Chinese who prepared it by burning oil and allowing the flame to impinge on a small porcelain cone, from which the deposited carbon was removed at frequent intervals with a feather. The famous stick ink resulted from the compounding of this with a strong glue solution.[169]

R. H. Clapperton has shown that the recent researches of Sir Aurel Stein and Sven Hedin prove beyond doubt that the Chinese were .not only the inventors of rag paper, raw fibre (mulberry bark and bamboo paper) and paper made of a combination of raw fibre and rags, but also the inventors of loading and coating paper![170] We formerly used a china-coated paper to obtain the best reproduction of photographs with a fine screen, though this has now been replaced with less expensive and possibly more durable plastic coatings. But the idea originated with the Chinese.

A recent Chinese author, Li Ch'iao-p'ing points out that Chinese inventions opened up new fields of chemical manufacture in early times, but then remained stationary for centuries. One of their earlier contributions to medicine was the extraction of ephedrine from the herb *Ephedra*, a process credited to a very famous Emperor Shen Nung, who is supposed to have lived somewhere between 3000 and 2200 B.C.[171]

A two thousand year old rig for drilling salt wells was recently cited as a good model still for the modern cable rig of today's oil fields.[172]

Even in the design of clothing, they seemed to have a genius for hitting upon the best end-results, quite apart

168. Needham, J., *ibid., v*ol.1, p.231.
169. Stick ink: Stern, H. J., *Rubber: Natural and Synthetic,* London, Maclaren, 1954, p.118.
170. Clapperton, R. H. and William Henderson, *Modern Paper Making*, Oxford, Blackwells, 2nd.edition, revised, 1941, 376 pages.
171. Ephedrine: Bender, George A., "Pharmacy in Ancient China" in the series, *A History of Pharmacy in Lectures*, Parke Davis Pharmaceutical Co., 1957.
172. Oil rig model: see Edward Farber, reviewing Li Ch'iao-p'ing,, *The Chemical Arts of Old China* in *Scientific Monthly*, vol.68, June, 1949, p.430.

from the actual materials they developed. Thus it has been recently shown that the so-called 'Chinese sleeve' which permits each forearm to be inserted into the opposite sleeve, is more effective for keeping the hands warm in cold weather than either Arctic mittens, or a muff! Europeans adopted muffs and mittens -- but having investigated the Chinese pattern thoroughly, it now appears to be equally if not more effective. [173]

Although the 'clockwork' motor principle was taken to the Chinese from the West, their water clocks long antedated the European systems of keeping accurate time, and were certainly more dependable, especially when mercury was used in place of water. The complexity of these water-clocks has only recently been recognized as a result of the finding of some ancient documents sufficiently explicit and detailed to enable Needham and some associates to draw plans and diagrams of their operation. This was reported recently in the British Journal *Nature.*[174] These devices were highly ingenious, involving gear trains of several kinds, the speed being very exactly regulated by a most dependable and clever use of water or mercury. Knowledge of these seems to have come into Europe possibly during the Crusades. The clocks were connected with astronomical observations, in an endeavour to predict seasons, etc., more exactly. The interest was purely of a practical nature.

As we have already mentioned briefly, the Chinese had already discovered the uniqueness of finger prints, and quickly perceived how useful this could be for identification purposes. They were used during the T'ang dynasty as early as 618 A.D.[175]

According to a special report on the uses of natural gas, it is said that the Chinese were the first to use it. [176] Probably the Sumerians can dispute this claim. But the story goes that some villagers near Peiping were trying to put out a local brush fire, when they found one flame that could not be extinguished with water. "The practical villagers then built a bamboo pipeline, from the outlet to the village, and used the gas for heating brine to make salt." This is said to have taken place somewhere about 450 B.C. Whether they can be said to have 'invented' the use of natural gas or not is a questionable point -- but certainly they were very quick to see its practical possibilities. This is in exact contrast to the Romans who produced Cast Iron in considerable quantities but threw it

173. This is reported in an *Annual Project Report* issued by the US. Quartermaster Stores, Jan.-Dec., 1956, vol.1, p.401.
174. Needham, Joseph, Wang Ling, and Derek J. Price, "Chinese Astronomical Clockwork," *Nature,* vol.177, March 31, 1956, p.600, 601.

175. Haddon, Alfred C., *The History of Anthropology,* London, Watts, 1934, p.33.
176. Reported in *The Telegram,* Toronto, April 4, 1955, in a special section devoted to the use of Natural Gas; under the title "Gas and Pipeline too: way back in 450 B.C."

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all away because they did not recognize it as a potentially useful product.[177] As we have already remarked, the basic technology of all metallurgy is entirely non-Indo-European, even heat-treatment and case hardening being known before we 'discovered' it.

Indeed, in some instances, we not only never have improved upon the products of our instructors, but actually have not even been able to improve upon their methods of manufacture, where we usually shine. *Cire perdu* casting is still employed for small bronze statues of racing horses and such items, and even the use of cow manure for the mold has been retained from the most ancient times, to give the best results. This system is extraordinarily effective for casting hollow articles of intricate form, where the use of ordinary cores is quite impossible, and yet it is found in every primitive society that has any knowledge of metals, in every archaeological site bearing the remains of cultures who had developed metal casting skills, and virtually every high civilization, with the exception of Indo-Europeans, seem to have had knowledge of the art . . . almost exactly as it is done in Europe today. We therefore use the same basic methods as non-Indo-Europeans for casting hollow objects in metal as they used, just as we have adopted exactly the same method of moulding hollow objects in rubber (cored or slush-moulded) as the natives of Central and South America did.

Conclusions

Certain other contributions to our technology, notably in connection with the use of electricity and internal combustion engines, will be acknowledged in the next chapter. They will be used to illustrate some important aspects of this question as to whose contribution has been most important.

Although it will be possible to quote authorities who do not hesitate to say in so many words that we have invented virtually nothing, such sweeping generalizations need qualification. In the first place radical mixture has proceeded so extensively in Europe and America that it is no longer possible in many cases to say, for certain, which individuals do or do not carry some non-Indo-European genes. In other words it is no longer always clear who is truly Indo-European and who is not. But it is true to say that whatever inventiveness we have shown in the past three or four centuries has almost always resulted from stimulation from non-Indo-Europeans. Our chief

177. Forbes, R. J., Metallurgy in Antiquity, Leiden, Netherlands, Brill, 1950, p.407.

glory has been the ability to improve upon and perfect the inventions of others, often to such an extent that they appear to be original developments in their own right. We can also make some claim to have greatly advanced mass production methods. But it would surely be a great mistake to credit the improver with greater inventive ability than the originator. Moreover, the individual who tells the truth 99% of the time, but now and then tells lies, would hardly be termed a liar. By the same token, it does not seem proper to call a people 'inventive' who once in a while do invent something, but who 99% of the time merely adapt the inventions of others to new ends.

Paul Herrmann has written an interpretative survey of man's conquest of the earth's surface from Palaeolithic times to the present day. It is the work of one man, no small undertaking, and has therefore not the comprehensiveness one might desire, but it has the advantage of being a unified treatment. In his foreword he has this to say: [178]

> A further aim in writing this book was to weaken the very widespread conviction that our progress in the technological aspects of civilization represents, in any real sense, a greater achievement than that of our forebears. The liberation of atomic energy probably means no less than did the invention of the fire drill or the wheel in their day. Both discoveries were of immense importance to early man.

Needham says that the only Persian invention of first rank was the windmill, and apart from the rotary quern whose history is not quite certain, the only European contribution of value, mechanically speaking, is the pot-chain pump. [179] This gives us two claims to originality. Compared with the originality of other cultures prior, let us say, to the 15th century A.D., we certainly did not shine in this direction. Yet we have advanced technology so far ahead of all previous civilizations that there must be some more subtle reason which will bear investigation.

It could be argued that primitive people do not invent much either: but this is easily accounted for. They do not see any need to do so. When that need arises, they are ingenious enough, though for reasons we may consider subsequently, they actually resist innovations as a rule.

The next chapter will be devoted to an examination of two things. First, the evidence for this lack of originality among Indo-Europeans; and secondly, the evidence for the almost total lack among non-Indo-Europeans of that "impulse towards philosophical speculation" as Maritain so aptly put it, [180] which has finally given us the great technical superiority we currently enjoy over other cultures.

178. Herrmann, Paul, *Conquest by Man,* New York, Harper, 1954, p.xxi, xxii.
179. Needham, Joseph, *Science and Civilization in China,* Cambridge University Press, 1954, vol.1, p. 240.
180. Maritain, Jacques, *An Introduction to Philosophy,* translated by E. I. Watkin, New York, Sheed and Ward, 1937, p.26.

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