Chemical Engineering Around the World

Edgar L. Piret, *Editor*

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Ancient Greece

Most people are under the impression that philosophy and the liberal sciences were the main arts cultivated in Ancient Greece and that applied science was of much leu concern to everyone. This conception derives mainly from the fact that the technical inventions and the personality of the engineers were of very little interest to the ancient authors. The glory that engineers have been invested with from the time of the Renaissance and thereafter was entirely absent from Antiquity. In spite of the democratic spirit that prevailed in Ancient Athens, the mental aristocracy regarded engineers as inferior. But if we judged the Ancient Greeks by their works of technical art, then we should come to the conclusion that, along with philosophy, they also cultivated the applied sciences and gave themselves to the utilization of nature's raw materials for the production of useful things; that is to say, they were practicing, on a small scale of course, an elementary chemical industry. Consequently, they must have been aware ot some basic principles of that branch of knowledge which in our days we call chemical engineering.

Greek mythology tells us that Prometheus, the friend of the gods of Mt. Olympus, stole fire from that mountain and brought it to man, thereby giving him the means by which he might put to his service a great power of nature in order to process metals, make pottery, warm himself, and cook his meals. To punish Prometheus for his theft, the gods chained him to a rock of Caucasus and sent an eagle there to eat from his liver. Prometheus may be deemed a symbol of all those who sacrifice themselves for the welfare of mankind.

Outside the realm of mythology, around 500 B.C., Heraclitus promulgated the axiom of perpetual flow; hence constant mo-

* *Chemical Engineering Consultant, Athens*

tion and change. The world was thought to be made up of four basic elements, earth, air. fire and water. These elements, which represented the basic nature of the world, were considered as changing from one state to the other, that is, from a solid state into a liquid, into an aeriform state. Besides, it was believed that matter was also converted into fire, or energy, and vice versa.

On the other hand, in 450 B.C. Democritus propounded the theory that all substance was composed of moving atoms and space and propounded, at the same time, the existing contrast between the true world and the world perceived by our senses. "We call," he says, "something sweet or bitter, cold or hot, white or black, while in reality it is mere atoms and space we are talking about. All other things are subjective impressions and illusions (false ideas). As far as matter is concerned, it is divided into such tiny particles, the atoms, that one cannot notice them," We see how those theoretical principles of the early Greeks coincide with our present-day scientific beliefs.

Metallurgy was the prime man-made industry, and it is known that that industry had made considerable progress in Ancient Greece. Nothing is known as to how and when the smelting processes were invented, but it is certain that much of this knowledge had its origin among .the Oriental peoples. Greek mythology attributes these inventions to various mythical characters, gods, demigods, heroes, kings, etc.

A copper saw and golden rings were found on the island of Thera among ruins dating back to the year 2000 B.C. Gold, silver, lead, copper, and bronze were known to the people of the Mycenaean era (1500 B.C.). The bathtub of Menelaus, the King of Sparta who was the husband of Helen of Troy, was made of silver. Endless piles of sand which had been washed for gold have been found in Macedonia. The Greek island of Cyprus is considered as the homeland of copper and as the source oi its name *(cuprum).*

One of the greatest and most important metallurgical installations, existing since the Mycenaean era, used to be at Laurium, near Athens, where rich deposits of galena, with a

silver content, were being intensively exploited. The slag and ruins that have been found bear witness to the fact that a second sorting job followed in the open besides the one that took place in the underground galleries. Then the ore was crushed and ground in mortars and in rotating mills made of granite and enriched by water washing. Some of the numerous washing installations found at Laurium were 60 ft. long. The pulverized ore was put on a ramp, through which water flowed, running onto it from slits. The light earths were swept into the draining channels, where they deposited the ore they carried. The washed ore was spread on the central flat surface to dry.

Vertical annular furnaces lined with firestones made of trachyte were used for smelting the ore. Firewood was used as fuel. Through this process, lead with a silver content was derived and then, by a following cupellation, was separated into silver and litharge. To obtain lead, litharge was subjected anew to smelting with charcoal. Copper and iron were smelted in a similar way.

In the fourth century B.C. Laurium employed around 20,000 people. When its ore mines started to be depleted, new smelting methods were put into practice on the older slag. Even today entire hills of the slag of that time still exist. Herodotus (450 B.C.) states that the Athenians used to paint their ships with minium; in other words, they knew how to oxidize lead. He also refers to a forger who made gold-plated counterfeit coins.

Iron became known around 1000 B.C. The coppersmith Glaucus (seventh century B.C.) invented a method of welding iron by the application of heat, and Theodorus of Samos invented the art of casting iron and of making cast-iron statues. Theophrastus (third century B.C.) describes the use of charcoal and coal in the art of extracting iron. He also describes the tanning of leather, the preparation of alcoholic drinks from cereals and fruits, and the processing of litharge.

The art of ceramics made exceptional progress in Ancient Greece. The potter's wheel had been in use in Crete since 1800 B.C. for manufacturing jars of all sizes, including some taller than a man, which were used for storing grain. Also the manufacture of fine clayware during the same era reached such an amazing height of perfection, the walls becoming so thin, that archaeologists have called it *eggshell ware.* The manufacture of ceramics presupposes the possibility of constructing proper kilns in which the temperature can be accurately regulated. Ruins of such kilns were found at various places. The manufacture of glass and of small vitreous receptacles and jewels was also known.

Grapes and olives were pressed primarily by foot, as has been proved by the sizable stone-cut basins that have been found, but the lever had begun to be put into use for pressing olives in those distant years of Greek Antiquity. A Greek pot of the sixth century B.C. portrays an olive press weighted by two heavy stones hung by ropes to a long wooden lever, from which another figure is also suspended—apparently for added weight. The screw press was invented in Greece in the first century B.C.

The weaving of wool and linen was practiced in Greece from prehistoric times. In the classical era that craft, and the art of dyeing as well, reached great perfection.

The first pump is attributed to the Greek mechanic Ctesibius (third century B.C.), of Alexandria. It was made of a bronze cylinder and valves with a wooden piston. The conveying screw was invented by Archimedes (287-212 B.C.), the famous mathematician, and is called Archimedes' screw. He was also the first to draft the laws of hydrostatics and to apply specific gravity in testing the genuineness of a golden wreath.

The use of pipes in conveying liquids was widespread. The plumbing system of Minos's palace (1800-1600 B.C.) was of clay pipes. Engineer Eupalinus constructed, in 532 B.C., a one-mile aqueduct of clay pipes and later (180 B.C.) Greek engineers constructed at Pergamos a wonderful aqueduct with perforated stones for pipes; it had a diameter of 1 ft. and carried water from a height of 1,000 ft. at a pressure of 300 lb./sq. in.

Around 230 B.C. the famous engineer Philon lived in Byzantium. Among his technical inventions was a combination of valves which made it possible for equal quantities of a liquid to pour out automatically from a revolving vessel at each revolution. He also invented various apparatus for mixing liquids and automatic devices based on the principles of hydrostatics. Philon made the first thermometer, consisting of a glass bulb full of liquid and a glass tube connected to it. An interesting fact about Philon is that although all his plans were worked out for large projects, he carried them out first on a small scale, thus establishing the pilot plant principle 2,200 years ago.

Modern Greece

Industry

The Greece of today for a long period remained an agricultural country, the development of a chemical industry starting only in the twentieth century. The present income of all small and large industries represents just about 20 per cent of the total national income.

The major part of her industry consists of small enterprises. The total annual production of the chemical processing industries does not exceed $200 million, but its growth has been and will continue to be constant.

The local chemical industry covers about 80 per cent of the needs of the country and produces mineral acids, fertilizers, glass products, cement, organic dyes, pharmaceuticals, leather, oils and fats, soaps, lubricants, etc. A large petroleum refinery is now being erected, and a large plant for the production of synthetic ammonia from lignite is soon to be constructed.

Education and Research

The first Greek chemists studied in universities and technical schools abroad, but since 1917 the Athens University has had a special branch for chemists and the Technical University, a special school for chemical engineers. In 1940 a new chemical school was founded at the University of Thessaloniki.

The curricula of all these schools are similar and the graduates follow the same careers either in industry or in other fields.

In 1925 there were in Greece about 400 chemists and 60 chemical engineers. Since then the number of chemists has grown to about 1,400 and that of chemical engineers to 500. Of these about 50 per cent are engaged in industry, the rest in government projects and private institutes.

In spite of the small-scale activities of the chemical industry an effort is being made by several divisions for the study and the creation of special processes better adapted to the local conditions. The State and various organizations and associations have founded numerous institutes for the study of better industrial methods to exploit domestic raw materials and agricultural products, such as ores, cotton, tobacco, raisins, wines olive oil, olives, figs, etc.

An important private institute is the Institute for Chemistry and Agriculture Nic. Canellopoulos of the Hellenic Company of Chemical Products and Fertilizers, the largest chemical firm in Greece, which produces mineral acids, fertilizers, various chemical products, glasses, firebricks, insecticides, fungicides and many other agricultural chemicals and owns and operates important mines of pyrites (in Greece and Cyprus), nickel ores, lignite, etc. The institute has special laboratories for the study of scientific and technical problems of the company and of Greek industry and agriculture as well.

Considerable progress has been made since World War II in designing and manufacturing machines and entire plants for the chemical industry. Numerous plants for the extraction, hydrogenation, and refining of fats and oils, for the production of lubricating oils, for the food industry, for the treatment of ores, etc., have been designed and constructed in the country.