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CHAPTER I

In The Beginning

Who can tell when engineering began? Many thousands of years ago when the human race had to concern itself primarily with using the earth and the products of the earth for survival, we may consider that engineering in its earliest form began. It is true that no one race and no single era may properly lay claim to the parenthood of engineering; but every race and every era and every phase of civilization, and even every climate, may be said to have made some significant contributions to the science which is acknowledged to be an important profession of this modern day, to ease the burdens and "benefit mankind."

We read that the ancient Chinese mariner steered his junk with the help of a seashell filled with oil, upon which floated a bit of reed, enclosing a magnetic needle which pointed always to the Southern Cross. Certainly some primarily basic acquaintance with principles of science seems indicated here.

Water was a source of survival for the ancient. He had to have water to irrigate his land, to quench his thirst, to keep his flocks

and herds in good productive condition, and to have routes for his travel and commerce. Thus we find evidence in various parts of Asia, Europe, and Africa of chains of canals, storage lakes, wells and conduits of ancient origin. The arid sections of the land had to be irrigated by use of the sometimes complicated water systems. Ancient Judea had a tunnel over 1700 yards long constructed for the purpose of bringing water from the Virgins' Pool in the Kedron Valley to the Pool of Siloam. The city of Jerusalem was thus provided with water while the surrounding country was in possession of the enemy.

In Homer's[2] ILIAD, written three thousand years ago, the famous author of the ancients described the forging of a shield in words that may be said to have their counterpart in modern engineering specifications. Herodotus,[3] 2500 years ago, tells about what he learned from the Egyptians concerning the building of the pyramids. In a later book this same author relates the story of the bridge built by Xerxes across the Dardanelles, and the construction of the canal through Athos.

2-HOMER - Greek poet. Flourished about the 9th Century, B. C. Principal figure of ancient Greek literature. First European poet.

3-HERODOTUS - 484? - 425? B. C. Greek historian. Called the "Father of History."

A nineteenth century engineers found a parallel between that ancient work and that of General Grant in the campaign before Vicksburg.

Rome had her famous aqueducts outside the city. They varied in length from 10 miles to 60 miles, with most of the construction being underground. Remains of these and other famous Roman water supply systems are still in existence. One must agree that at least an elementary acquaintance with hydraulics must have been developed by early Roman engineers.

The engineer of ancient times had to use any method at hand to reach his objective. He had no physical laws scientifically established. He had no recourse to helpful formulae, or any theorem of Bernuoli; but when one considers the ancients had knowledge of and used the lever, the roller, the inclined plane--knew water seeks its own level, built dykes and dams--one must admit they left to posterity some well-established facts, discovered by methods that at best could be only empirical.

We read about the ancients and the ways they developed methods of overcoming obstacles of various kinds. They cut tunnels through

mountains, directly through rock! What manpower must have been expended on these old works! Explosives were unknown then. The work had to be done by whatever ingenuity the leaders possessed. The Tombs of the Pharaohs, the Pyramids of Egypt stand as a lasting token of man performing the impossible. Small wonder we find evidence that in Egypt nearly 6,000 years ago there was a leader who bore the honored title of "Superintendent of Works."

Ancient stone bridges, the durable roads and aqueducts, the water supply systems, the temples, the amphitheaters and palaces were a feature of the Roman Empire when she ruled the world. But there was available no modern engineering formulae. The printed word, so necessary to modern contracts and specifications, was unknown. Everything had to be done with tremendous output of labor. Climate and geographical location had a great influence also on the early development of engineering. Countries that were arid had to survive by overcoming the terrible problem of scarcity of water. On the other hand, nations that did not have this water problem, such as ancient Greece, did not

have to be concerned with water storage too greatly. Their problem was to overcome the difficulties arising in a country located on the sea which had to be used for travel and commerce. Hence it is no surprise for us to find that the natural surroundings of the Greeks turned their thoughts to roads and bridges and harbors. They had to overcome a water hazard in reverse.

Just a thought about some ancient road building. The early Romans mastered this art. "All roads lead to Rome" was no empty sentiment in those early days. It appears that military movements were the highest consideration in the construction of those ancient highways. The historian, Buchholz, reminded us that "wherever the conquering arms of the Romans were carried, through Gaul, into Germany, and over to Britain, through Greece into Asia Minor and India, to the very gates of Cathay, the engineer followed, and often led the way."

Yes, there are written and material records still in existence of the early engineering skill possessed by the ancient peoples of the earth. Military expediency demanded fortifications for defense, and

devices to reduce fortifications. Cities had to be defended, and walls and moats often proved the last bulwark against annihilation by the enemy. Small wonder that the engineer of those early days was very close to the ruler of the nation, and that military engineering may be considered the oldest branch of the profession.

The Greeks made many contributions to the profession of engineering. Ctesibius[1] invented a two-cylinder force pump made of bronze. Hero invented a leveling and alignment instrument for use in surveying, and in addition he developed a steam jet engine. And most people in the modern day have some idea of how Archimedes became famous for his projectile hurling mechanism, the screw control for raising and lowering water levels, and for having developed the weight-water displacement theory. Archimedes surely was the earliest protagonist of "push button" engineering.

Architectural engineering, in turn, owes much of its early development to the Roman, Vitruvius[2], who lived in the first century A. D.

1 - CTESIBIUS - 2nd Century B. C. Alexandrian Greek mechanical genius. Other inventions ascribed to him are a water clock and hydraulic organ.

2 - VITRUVIUS - Roman architect - (Marcus Vitruvius Pollio) 1st Century A. D

and wrote a thorough treatise on architecture. This work was the building and designing authority for many subsequent centuries. A famous contemporary of Vitruvius was Sextus Julius Frontinus,[1] soldier, and water commissioner of Rome. He wrote not only books on military strategy, but a very famous one describing in detail the Roman aqueducts and water supply systems.

Most of the ideas set down thus far concerning the very ancient peoples encompass the centuries before the Christian era. With the decline of the Roman Empire it appears that interest and activity in the arts and sciences also went into a decline. For ten centuries it appears that while the ancient roads and structures and water systems continued to serve humanity, no actual attempt, according to the historians, was made to develop new ideas and benefits accruing from the previous experiences and work of the engineer. The so-called Dark Ages,[2] the thousand years or more between the fall of the Roman Empire and the

1 - SEXTUS JULIUS FRONTINUS - Flourished 74 A. D. Roman administrator and writer. Probably water commissioner of Rome.

2 - APPROXIMATE TIME FROM THE FALL OF THE ROMAN EMPIRE, 476 A.D., TO THE RENAISSANCE PERIOD WHICH BEGAN IN THE 14TH CENTURY, A.D. ALSO KNOWN AS MIDDLE AGES.

coming of the Renaissance, were indeed years of darkness as regards human progress. Engineering was no exception. Just as did all kinds of learning, literature, the arts, even the habits, customs, and well-being of the people, suffer in those years, so did engineering suffer. But the coming of the Renaissance changed the picture. Here engineering, together with the arts, literature, education, and living conditions—all those things which add to the happiness and progress of both nations and individuals—enjoyed the development and encouragement so necessary to new and continued progress.

It's a little hard to distinguish the beginnings of engineering and the beginnings of science but it is interesting to note that very early in history there came into being the title of Pontifex Maximus which possibly, and perhaps probably, meant "The Master Bridge Builder;" and it is very interesting to note that many of the civil heads of the Roman Empire bore this title as did, and does to this day, His Holiness the Pope. While it is not necessarily proof, it is very interesting to speculate that engineering in the form of bridge building was recognized as an

important adjunct of both lay and ecclesiastical life at such an early date.

The title of Pontifex Maximus goes back to the beginning of recorded history and it is indicated that one of the early legendary kings of Rome, Numa Pompilius, conferred upon one Claudius the title of Pontifex Maximus. It's interesting to note that his function was to arrange the funerals and it is conceivable that the bridge alluded to here was that structure which spans the great chasm between earth and heaven.

A little later in the Middle Ages, as the story goes, there was a group known probably as "The Order of the Bridge Builders." They were ecclesiastical in origin and wore white tunics with a red keystone as a symbol. They were called into action when any considerable arched structure was to be built. Their work was notable in the building of the great arch bridge over the Rhone at Avignon and they were in evidence at all the considerable structures in Europe. Whether or not the Pope was the titular head of this organisation or whether they had

any connection with the title of Pontifex Maximus is not clear. The only thing that is clear is that even in that early day the building of bridges and other similar structures was of so much importance to the defense of cities it assumed somewhat the character of a profession and was not left in the hands of mere workmen. Perhaps this Society of Bridge Builders was the first of our great professional societies.

General William Barclay Parsons, in his book published in 1939, Engineers and Engineering in the Renaissance, wrote what is probably the finest work on the history of engineering of the Renaissance period. The major portion of the general's life was devoted to this study. He combed the libraries of Europe. He spent many months at the British Museum, and the Bibliotheque National in Paris, and finally visited the Vatican Library in Rome. Here the General found a tremendous amount of material concerning early engineering accomplishments; but it was difficult of access because of an almost complete lack of a cataloging system and modern library classification and

arrangement. Parsons returned to this country and with the help of Nicholas Murray Butler of Columbia University succeeded in interesting the Carnegie Endowment for International Peace[1] in the matter of providing funds for the modernization of the Vatican Library. This was carried out with the help of outstanding American librarians, and with the approval and co-operation of the Vatican; and Parsons was thus able to complete his research and obtain access to a vast amount of valuable material that forms a major portion of his work.

In describing some of the factors that motivated this study of many years, Parsons pointed out that the modern world had practically no conception of the history of engineering. The world, he maintained, knew how cathedrals and churches and temples and bridges and roads were planned, but they had no knowledge of how they were actually constructed. How was it possible, he asked, when man's knowledge of the forces of nature was still so elementary, to control those forces sufficiently to reach the amazing heights that early engineer-

1 - ENGINEERS & ENGINEERING IN THE RENAISSANCE - W. B. Parsons 1859-1932
1939 The Williams & Wilkins Company
Introduction - Nicholas Murray Butler

ing did achieve? His research, his years of study, and finally the finished product, became a book that belongs with the literature of the ages.

The scope of the contribution of the Renaissance, especially in the field of engineering, was aided and stimulated by one of the greatest intellects of all time, Leonardo da Vinci.[1] Probably best know for his paintings of the priceless "Mona Lisa" and the "Last Supper," da Vinci was a military engineer and architect of the highest ability. He was outstanding not only as a painter, but as a sculptor and musician. His own writings, of 5300 pages, describing his experiences, his experiments, and his varied engineering works are valued records of his wide range of endeavors. His notes and sketches, his writings and drawings, form the permanent history of an outstanding engineer and artist. They have been reproduced for succeeding generations for study and guidance and unbounded admiration. How many of us know anything about his early experiments with flying machines?

1 - LEONARDO DA VINCI - 1452-1519. Perhaps the greatest engineer of all time. Supreme in many fields, his contribution to human progress is incaloulable.

His was a dream that remained unfulfilled--but he knew that years to come would see man conquering the air. One of his old notebooks says: "If the heavy eagle on his wings stays up in rarefied air, if large ships under sail move over the sea, why cannot man also, clearing the air with wings, master the wind and rise up, a conqueror, on high?"

The apparatus he strove to perfect for his flying experiments resembled a bat. Destined never to fly, it remained a dream, but a dream that came true centuries later to the Wright brothers above the sands at Kitty Hawk, and had its ultimate realization in 1927 when Lindbergh[1] piloted his tiny monoplane, "The Spirit of St. Louis," non-stop from New York to Paris, while the world waited in silent prayer. The word aerodynamics has a modern connotation, but da Vinci, nearly 500 years ago, was the first man who knew much of this science.

It is not appreciated by many how closely art and technology or art and engineering were in the days, for instance, of the Renaissance. The greatest artists were the greatest engineers and the two were

1-LINDBERGH, CHARLES AUGUST, Master Airman. 1902-

necessarily hand in hand. The great engineering works of Michelangelo were just as truly engineering as architectural; and his design of the great Dome of St. Peter's in Rome without guidance from written principles or formulae was certainly one of the most tremendous engineering achievements the world has ever seen. It's true he had the great Dome of the Pantheon as a model and it would be interesting to know from what model the Pantheon was designed.

In the field of sculpture too, of course, the casting of the bronze was just as important as the cartoons and the drawings of the designer. It is said that it took Ghiberti only a few days to design the bronze doors of the Baptistry in Florence but that it took him twenty-one years to cast them. The artist not only drew and chiseled, but cast his work as well. The story is told in Florence of Michelangelo's twitting Leonardo as the man who could draw this picture of a statue of the Collioni but could not cast it.

Those of us who are interested in the development of engineering find it of very great importance in the development of fine arts for

after all the artist had to be somewhat of an artisan as well. There had to be power behind Michelangelo's chisel; and in the negative sense, if Leonardo had only been satisfied with the then-current media, his "Last Supper" might have been saved for us in its original glory in Milan.

No reference to engineers of the past would be complete without some mention of Benvenuto Cellini,[1] born in 1500 A. D. He is acknowledged to be the greatest artist in gold, silver, and precious stones that ever lived. A practical mechanical engineer, his foundry work--the casting of huge bronze pieces--has never been surpassed. His own story, written by himself, of his bronze statues of the Medusa and Perseus, and the many obstacles and discouragements he had to overcome in casting these statues, is an inspiration for all sculptors, artists, and engineers of whatever era.

The list of individuals from the ancient and middle ages who had some significant part in the development of engineering is long

1 - CELLINI, BENVENUTO * Italian artist, sculptor, metalworker, author. 1500-1571 A. D.

and varied. Histories show the accomplishments of men who, by any measuring device, were outstanding in the field. But, one may ask, what is the importance of all this to a modern story which has for its theme the contribution of the Newark College of Engineering to modern scientific education? They did what we tried to do--to make the lot of man easier and life richer.

We must consider another very important fact. When 1492 came Christopher Columbus discovered a new continent. Here started the race for colonization and conquest. The civilized nations of Europe contended for possession of the great new land. The many voyages to take possession of the western empire soon convinced the leaders in Europe that artisans, mechanics, and engineers were a prime necessity in the new world. Almost concurrently with the discovery of America the Renaissance in Europe was enjoying its most flourishing period. In the hundred years before and after Columbus' voyage of discovery history shows that Botticelli, da Vinci, Rubens, Raphael, Cellini, and many other famous men were at the height of their accomplishments in the arts and engineering.

Vespucci,[1] Pisarro,[2] Balboa,[3] Magellan,[4] Cortez,[5] Drake,[6] and Raleigh[7] followed in the footsteps of the Genoese on voyages of exploration and discovery to the new land to the west. In literature

1 - VESPUCCI, AMERIGO - 1454-1512. Italian navigator. Explored northeastern coast of South America (1499-1500). Explored coast of Brasil (1501-1502). America was named for him.

2 - PIZARRO, FRANCISCO - 1476-1541. Spanish Conquistador. Explored northwestern South America. Conquered Peru. (1523-1541)

3 - BALBOA, VASCO NUNEZ DE - 1475-1519. Spanish Conquistador. Crossed Isthmus of Panama and discovered Pacific Ocean (1513).

4 - MAGELLAN, FERDINAND - 1480-1521. Portuguese navigator. Discovered Strait of Magellan (1520) during circumnavigation of the globe. Although he did not complete the journey, he led the way and proved that the world curved.

5 - CORTEZ, HERNANDO - 1485-1547. Spanish Conquistador. Explored and conquered Mexico (1519-1527).

6 - DRAKE, FRANCIS, SIR - 1540?-1596. English navigator and admiral. First Englishman to circumnavigate the globe (1577-1580). Explored west coast of North America, sailing as far north, possibly, as the present state of Washington.

7 - RALEIGH, WALTER, SIR - 1552?-1618. English statesman and man of letters. Conceived and organized colonizing expeditions to America which ended tragically with the "lost colony" on Roanoke Island, Virginia.

Erasmus,[1] Cervantes,[2] Bacon,[3] Shakespeare,[4] and Ben Jonson,[5] were writing for the ages; and science itself had great impetus during the Columbian period when it provided men like Copernicus, Napier, and Galileo.

The Renaissance was thus flourishing in Europe. In the meantime the new world was being colonized. Slowly but surely European nations were obtaining footholds on the shores of America. Yet the process was a slow one for our histories show that the first permanent settlement was that by the English at Jamestown, Virginia, in 1607, 115 years after the first voyage of Columbus. Coupled with

1 - ERASMUS, DESIDERIUS - 1469?-1536. Dutch humanist.

2 - CERVANTES, SAAVEDRA, MIGUEL DE - 1547-1616. Spanish novelist, dramatist, and poet.

3 - BACON, FRANCIS - 1561-1626. English philosopher and statesman.

4 - SHAKESPEARE, WILLIAM - 1564-1616. English poet and dramatist.

5 - JONSON, BEN - 1572-1637. English dramatist and poet.

this, and the landing of the Pilgrims 13 years later in 1620 at Plymouth Rock, the English appeared to have obtained a running start in the race to take possession of the new world. The French, Spaniards, and Dutch all followed and took possession of various sections of the country.

What significance may we draw from the fact that so many of the European nations combined to furnish the men and materials for the young continent? We know that among the nations of the old world the French were probably foremost in pure science, the Germans in technology, and the English in marine engineering, as would befit an island nation. Britain's sea commerce was her very lifeline, and her dominance of the world's oceans gave her leadership among nations of the earth. For centuries "Britannia Rules the Waves" was indeed no exaggerated statement--it was a fact.