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# THE AMAZING GENIUS

By ELDON G. CONSTANCE, CER. ENG. 1

EDITOR'S NOTE: This is a second article in a series of biographies of famous engineers by Mr. Constance.

Many great men have sprung from the ranks of the common people and some with a serious handicap. So it was with Leonardo da Vinci. The life of Da Vinci, who was born in 1452 in the little Italian town of Vinci, the illegitimate son of an obscure public notary and a pretty peasant girl, reads like a fairy tale and makes one gasp with amazement at the scope of his genius and achievement. Upon nearly all of the sciences and the arts, this versatile-minded master has left his lasting impression, especially in the field of engineering.

Early in his youth Leonardo was apprenticed to a goldsmith, artist, and somewhat of a dabbling engineer, Andrea del Verrocchio. It was under this man's patient tutelage that Leonardo spent his impressionistic age and developed that tremendous inquisitiveness of mind that followed him to his death. After leaving this loving friend, Leonardo embarked upon a career of practical and research work covering a very large field. Everything he did was for personal satisfaction primarily. His voluminous notebooks teem with ideas and conclusions that he obviously never intended to publish from the manner in which he wrote them—a singular left-handed style of writing, reading from right to left known as mirror writing because it can be read best with a mirror—interwoven with diagrams and sketches of his many conceptions, written and drawn as the ideas were born, for later reference. From these papers may be gleaned the fact that as an engineer he was even greater than as an artist though by the latter title the world at large knows him best. His work as a scientist and engineer may well be divided into two parts, the practical and the theoretical.

In the field of practical engineering his versatility covered nearly all of the modern specialized fields. He was at different times a hydraulic, mechanical, mining, military, civil, structural, metallurgical, chemical, architectural, and an aeronautical engineer. His accomplishments may best be told by himself in his letter to Ludovico Sforza, Duke of Milan and patron of the Renaissance, in application for an appointment, as follows:

Having, most illustrious sir, seen and considered the experiments of all those who profess to be masters in the art of invention of the apparatus of war, and having found that their instruments do not differ materially from those in general use, I venture, without injury to anyone, to make known to Your Excellency certain secrets of my own, briefly enumerated as follows:

1. I have a process for the construction of very light bridges, capable of easy transport, by means of which the enemy may be pursued and put to flight; and others more solid, which will resist both fire and sword, and which are easily lowered or raised. I know also of a means to burn and destroy hostile bridges.

2. In case of the investment of a place, I know how to drain moats and construct scaling ladders and other such apparatus.

3. Item; if, by reason of its elevation or strength it is not possible to bombard a hostile position, I have a means of destruction by mining, provided the foundations of the fortress are not of rock.

4. I know also how to make light cannon easy of transport capable of ejecting inflammable matter, the smoke from which would cause terror, destruction, and confusion among the enemy. (Note here a Fifteenth Century forecast of smoke-screens and poison gas.)

5. Item; by means of narrow and tortuous subterranean tunnels, dug without noise, I am able to create a passage to inaccessible places, even under rivers. (Note our modern river tube in Fifteenth Century.)

6. Item; I know how to construct secure and covered wagons for the transport of guns into the enemy's lines, and not to be impeded by ever so dense a mass, and behind which the infantry can follow without danger. (A possible likeness of our modern tank.)

7. I can make cannon, mortars, and engines of fire, etc., of form both useful and beautiful, and different from those at present in use.

8. Or if cannon happen to be impracticable, I can replace them by catapults and other admirable projecting weapons at present unknown; in short where such is the case, I am able to devise endless means of attack.

9. And, if the combat should be at sea, I have numerous most powerful engines both for attack and defense; and ships which are both gun-proof and fire-proof; also powders and inflammables. (Note similarity to modern armored battleships.)

10. In time of peace, I believe that I can compete with anyone in architecture, and in the construction of both public and private monuments, and in building of canals. I am able to execute statues in marble, bronze, and clay; in printing I can do as well as anyone else. In particular, I will undertake to execute the bronze horse in the eternal memory of your father and of the very illustrious house of Sforza, and if the above-mentioned things appear to you impossible or impracticable, I will offer to make an attempt at it in your park or in any other place Your Excellency may please to choose, to which I commend myself in all humility. (Mechanical Investigations of Leonardo da Vinci, p. 43.)

The above letter sounds rather egotistical, but this "I" could and did do most of the things enumerated. While in the employ of Ludovico Sforza, Lorenzo the Magnificent, and Cesare Borgia, Leonardo built and maintained canals and waterways in the Duchy of Milan, undertook the canalization and irrigation of the plains of Lombardy and waters of the Arno, and took decided interest in the tidal problems of the Caspian Sea, and many other hydraulic engineering schemes. For a period of seven years Da Vinci was appointed engineer-in-ordinary and painter to the

French king, Louis XII. Leonardo was also called as consultant for some architectural problems on the Cathedral of Pavia, near Milan.

Most of his employment, however, was as a military engineer. Among the numerous inventions and diagrams listed in his notes along the military line are:

1. Mortar for throwing bombs and shrapnel.
2. Cylindrical bullets with vanes cut into their shafts like modern aerial bombs.
3. Method of rifling cannon.
4. Diagram of a machine gun.
5. Drawing of an armored wagon.
6. Description of a type of submarine.
7. Description of a life-preserver for use in sea wrecks.

Some of Leonardo's other inventions of a more peaceful use are:

1. Machines for digging canals.
2. Pile-drivers.
3. Jig-saw.
4. Speedometers, both for water and land vehicles.
5. Spring-driven automobile.
6. Spring-driven helicopter.
7. Parachute.
8. Elevated roadway systems for cities.
9. Flying machine.
10. Architecture supports.
11. Measuring devices for surveying.

The foregoing list could be continued almost without end, so diversified were his investigations.

In the theoretical field he was a veritable intellectual giant, surpassing even his practical achievements, for he understood the principles of astronomy, paleontology, geology, mathematics, physics, chemistry, geometries, mechanics, and many others. One hundred and fifty years before Galileo Galilei was sentenced by the ecclesiastical tribunal for proclaiming the world's movement, Leonardo wrote, "The sun does not move, the earth is a star." To a large degree he anticipated Newton, pointing out the universality of gravitation. In geology Da Vinci forestalled our modern investigators by stating that the Biblical flood was a local rather than a universal inundation. Naturally, in his numerous excavations, Leonardo's curiosity became aroused by the rock strata and fossils. From its alluvial deposits the River Po was estimated to be at least 200,000 years old by Leonardo.

The theoretical sciences involved in engineering, as well as the preceding sciences, received Da Vinci's scrutinizing attention. With true engineering discernment his insatiable keen mind ferreted out the "why" behind most engineering phenomena. Mechanics, both statics and dynamics, were studied and the conclusions reached, in most instances, are remarkably close to the modern accepted views. In dynamics Leonardo worked out original explanations of force, inertia, and motion. His formulas for computations of the values of these various things are quite close to correct. His conception of law of falling bodies is very nearly true; near enough to show he understood this phenomenon. Da Vinci realized the difference between impulsive force and other types, concluding that impulsive force is dependent upon the angle of percussion. Most remarkable is Leonardo's recog-

nizing a definite coefficient of friction. In calculating the value of this original idea, he found the value to be 0.25; while this value is very wrong, the general importance of his conclusion is readily seen by the engineer. If his studies upon "sliding" and "rolling" friction had been known to Amontons and Coulomb they might have advanced farther in this line than they did.

Leonardo covers statics quite extensively, more so than dynamics, but this is natural since the way had been opened by his predecessors and there was no need for much original thinking. Nevertheless, he worked out conceptions of the centers of gravity, the lever laws, the laws of balance, the transmission of power, the strength of materials, and others, all accompanied by sketches, some quite in detail. His applications of the bent arm lever and realization of the potential arm laws undoubtedly carried Leonardo far along this particular line.

Da Vinci's work in dynamics and statics prepared the way for what, today, might be considered the greatest scientific and engineering achievement of his career—namely, aerodynamics and the principles of flight. Leonardo's "Treatise on the Flight of Birds" stands as a source of wonderment and awe at the ingenuity of the man to all who read it. He states the fundamental principles in aerodynamics in the following:

"To attain to the true science of the movement of birds in the air it is necessary to give first the science of the winds which we will establish by means of the movements of water. This science will be a degree of arriving at the knowledge of the winged creatures in the air in the wind." (The Mechanical Investigation of Leonardo da Vinci, pp. 148.)

He made countless studies of the different types of flight—namely, motionless flight, or soaring, flight with motion, and flight in general. He experimented and showed how birds change direction by shifting the center of gravity and action of the wind on planes of their wings and tail. Especially does he designate the foregoing facts in the soaring flight which might be compared to the tail rudder and warped wing surfaces the principal invention of Wilbur Wright. Leonardo recognized the probability of the screw type of movement in birds, for he designed a helicopter, operated by a spring, using that type of advance movement. While there is no absolute proof that Leonardo ever made an attempt at actual flight, he continually speaks of the "great bird" which would take flight from a mountain to startle the world with its possibilities. In his notebook are drawings of a bat-like flying machine worked by muscular power using a system of levers. He presented a truth which is today an axiom—that is, one should never fly close to the ground for if an accident occurs there is no time for righting the plane for landing. It has been said that if Leonardo would have had command of mechanical power, such as steam or gasoline, he would have constructed an aeroplane which might have flown.

In that period of wonderful achievements, the Renaissance, Leonardo da Vinci looms above his many famous contemporaries. Well may it be said that Leonardo has left the indelible mark of his amazing genius upon the world of engineering. Recently he was chosen by a group of engineering educators as one of the engineers of all times.