BIOGRAPHIES OF EMINENT WATER RESOURCES PERSONALITIES

Robert Sellin
University of Bristol, Bristol, UK

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Summary

“History, to paraphrase Leibniz, is a useful thing, for its study not only gives to men of the past their just due but also provides men of the present with a guide for the orientation of their own endeavours.” Thus begins Hunter Rouse’s classic work on the History of Hydraulics. Today we take a broader view of the subject including

hydrology, water resources management and water quality in the greater subject area. Here, in addition, the coverage has been brought up to date. This raises a difficult problem as it involves the work of those still living. Such biographies have purposefully been kept few in number.

There is no attempt to make this “water biography” comprehensive; to do so would be to embark on an endless task. Instead the selection has been made in an attempt to cover all the more important areas by recent biographies, and to select generally recognized outstanding personalities from the more distant periods.

It is impossible to do justice to the work of the ancients in this field since the names of the great innovators are not recorded and written records are few and far between. However it must be recorded here that the world owes a great debt to ancient civilizations and their success in controlling the use of water. One thinks especially of the Tigris and Euphrates basin, China and Egypt. After the Greeks came the Roman Empire, and here we have the first opportunity to study an important individual, Sextus Julius Frontinus, who was appointed water commissioner for the city of Rome in the year 97 of the Christian era. He wrote a detailed account of his work, which has come down to us intact.

1. Sextus Julius Frontinus, 40 – 103 A. D., Roman administrator and water commissioner

Frontinus began his career as a Roman military engineer and took part in many military campaigns. However, he is known to posterity for his work on the water supply of the imperial city of Rome. He was essentially a very successful administrator and this became apparent when in 97 AD he was appointed to the post of water commissioner for the city, the office whose management gives him probably his best title to eminence, and during the tenure of this he wrote his best known book *De Aquis Urbis Romae* (Concerning the water of the city of Rome). It is presumed that he held the office of water commissioner until his death in 103 AD.

The *De Aquis* is primarily a valuable repository of information concerning the aqueducts of Rome. But it is much more than that. It gives us a detailed picture of the faithful public servant, charged with immense responsibility, called suddenly to an office which had long been a sinecure and wretchedly mismanaged, confronted with abuses and corruption of long standing, and yet administering his charge with an eye only to the public service and an economical use of the public funds.

The administration of which Frontinus was a part was essentially one of municipal reform. The Emperors Nerva and Trajan both aimed to correct the abuses and favoritism of the preceding regime. They not only chose able and devoted assistants in their new policy, they themselves set good examples in this respect.

In Frontinus they found a loyal and zealous champion of their reforms. Realizing the importance of his office, he proceeded to the study of its details with the spirit of the true investigator, displaying at all times a scrupulous honesty and fidelity. He is an outstanding example, in the history of Rome, of civic virtue and the conscientious performance of unwavering duty.

In order to provide a record, both for his own use and also more widely throughout the Empire, he compiled this book, *De Aquis*, containing the results of the program he had laid down for himself at the outset of his work. He gives us the names of the aqueducts existing in his day, when and by whom each was constructed, at what points each had its source, how far they were carried underground and how far on arches, the height and size of each, the number of taps and the distributions made from them, the amount of water supplied to public reservoirs, public amusements, State purposes and private persons, and finally what laws regulated the construction and maintenance of aqueducts, and what penalties enforced these laws, whether established by resolution of the Senate or by edicts of the Emperors. And what he records is based not on hearsay, but on personal examination of all details, supplemented by the study of plans and charts which he had made.

The work is a simple and truthful narration of facts, containing a mass of technical detail essential to the complete understanding of the system described. The *De Aquis* will always remain a monument to the exceptional contribution that the early Romans made to the organization of water resources on a grand scale, and to its equally exceptional author.

2. Leonardo da Vinci, 1452 – 1519, Italian philosopher, painter and inventor

Leonardo was a product of the Italian renaissance. The natural son of a Florentine lawyer, he not only left his mark on Italian drawing, painting and sculpture but showed equal genius in music, natural philosophy, anatomy botany, geology, mechanics, engineering and architecture. No man has ever shown such a thirst for knowledge and such a gift for assimilating it and applying it in so many fields.

In the 1480s he practiced architecture as well as art in Milan and continued the habit formed in Florence of observing and recording nature in all her aspects. For a few months he read extensively in mathematics and mechanics at Pavia. On moving to Venice in 1500 he took on the planning and supervision of canal and harbor works over a large part of central Italy. Towards the end of his life he moved to Amboise in France; there he designed a castle and a canal connecting the rivers Loire and Saone.

Of interest to the history of water science are his collected writings *Del moto e misura dell'acqua*, a nine part treatise covering the following subjects: the water surface; the movement of water; water waves; eddies; falling water; the destructive force of water; floating bodies; efflux and flow in pipes; and mills and other hydraulic machinery. These overflowed with novel observations – often misinterpreted, to be sure, but far surpassing anything to be found in previous literature and much that was still to come. Typical of phenomena which he was the first to sketch or describe are: the velocity distribution in a vortex; the profiles of free jets; the formation of eddies at abrupt expansions and in wakes; the propagation, reflection and interference of waves; and the hydraulic jump. He advocated and developed the experimental method in hydraulics and used glass-walled tanks to observe internal fluid motion by the use of fine suspended particles.

Leonardo must also be credited with the correct formulation of at least one new principle of hydraulics. This was in the area of hydrostatics and embodied not only the principle of continuity but also the principle of force involved in the hydraulic press. However, it has to be said that he did not deal so successfully with the problem of flow through a notch or over a weir. All this, it must be remembered, took place before the year 1520.

3. Daniel Bernoulli, 1700 – 1782, Swiss mathematician and educator

Daniel Bernoulli was born at Groningen, the son of a mathematics professor who spent much of his life at Basel in Switzerland. This very talented family originally came from Antwerp and ultimately included eight members of mathematical note. Daniel studied under his father, Johann, at Basel after the latter returned to the vacant chair of mathematics at that university.

In his early career Daniel spent seven or eight years as professor of mathematics at St Petersburg. He also, at one time or another, held chairs in anatomy and botany. In the course of his life Daniel won or shared ten prizes awarded by the Paris Académie des Sciences for the solution of designated problems. The first of these, received at the age of twenty-four, involved the design of a clepsydra for the exact measurement of time at sea. Another, which he divided with his father, dealt with the inclination of the planetary orbits. Still another had to do with the nature and cause of ocean currents. In each of these he displayed considerable mathematical ability, to be sure, but above all a keen physical perception combined with the ingenuity to produce a solution regardless of the method used.

Many of Bernoulli's writings dealt with fluid statics and dynamics, but it was his *Hydrodynamica*, written at St Petersburg in the early thirties and published at Strasburg in 1738, which brought him his greatest repute. It is interesting to note that Daniel Bernoulli knew of the works of Isaac Newton and held him in the highest regard.

According to d'Alembert, in his Encyclopédie, hydrodynamics did not differ from hydraulics; nevertheless, "Bernoulli seems to have been the first to have reduced the laws of movement of fluids to principles sure and non-arbitrary, which no authors of hydraulics have done before him."

Of primary interest, of course, is the background of what is now called the Bernoulli theorem. In effect he solved the differential equation now carrying his name. He proceeded from the energy principles of Huygens and Leibnitz, assuming the fluid to consist of elements across the flow section. By treating a fluid as a mass of small elastic contiguous bodies he was able to develop the principle, amongst others, that "force" equals mass times acceleration. He was also able to see that the acting force was equal to the sum of the externally applied forces on the body of fluid, using vector quantities throughout. His wording is obscure, especially to modern readers, but, in essence, he was recasting Newton's laws of motion in a form applicable to a moving fluid. Building on this work, later contributors were able to develop the energy and momentum methods for fluids that we know today.

4. Antoine Chezy, 1718 – 1798, French Civil Engineer and water expert

Credit for not only the first but also the most enduring channel resistance formula is usually given to the French engineer, Antoine Chezy, yet the circumstances under which he made his contribution to hydraulics were such that it received little attention for many years after his death. He was born at Chalons-sur-Marne of a good though by no means noble family. He studied and later taught in a local parochial school and entered at the age of 30 the new federal school which was later named the Ecole des Ponts et Chaussées. He graduated with honors and from then onwards held a series of appointments of increasing responsibility in that organization. Under its first director, Perronet, he took an active part in the construction and inspection of bridges and streets in Paris.

In 1768 the Paris authorities commissioned Perronet and Chezy to investigate and design a new water supply system using the River Yvette which lay at a higher level and some distance from the city. It fell to Chezy to determine the cross-section of the canal and calculate the discharge. Since he could find nothing in the literature on the subject, he undertook his own investigation submitting his recommendations to Perronet in the form of a report. This report is lost but the files of the Ponts et Chaussées still contain his original manuscript. The following excerpt shows how well Chezy succeeded in identifying the basic principle controlling the velocity in uniform channel flow:

"…it is evident that the velocity due to gravity, which acts continuously,…..is only uniform when it (the water) no longer accelerates, and gravity does not cease to accelerate except when its action upon the water is equal to the resistance caused by the boundary of the channel; …but the resistance is as the square of the velocity because of the number and force of the particles colliding in a given time; it is also as the part of the perimeter of the section of the flow which touches the boundaries of the channel."
It is interesting to note that Chezy's original formulation involved simply a comparison of flow conditions between two streams having similar characteristics It is true that in a later memorandum he reduced the left side of his first equation to a numerical factor for purposes of simplifying computations, but he in no sense assumed – as it is sometimes claimed – that it was a constant for all streams; indeed he himself found it to change from one stream to another.

In conclusion it should be mentioned that Chezy's work had to wait a long time before it saw the light of day; it was in fact published by Clemens Herschel in America at the end of the nineteenth century.

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Bibliography

Abbott D., ed. (1985). The Biographical Dictionary of Scientists – Engineers and Inventors. London: Blond Educational.

Binnie G.M. (1981). *Early Victorian Water Engineers*. London: Thomas Telford Ltd.

Day L. and McNeil eds. (1996). *Biographical Dictionary of the History of Technology*. London and New York: Routledge Reference.

Frontinus J.S. (1998). *Stratagems and Aqueducts*. English translation by C E Bennett, (1925) Loeb Classical Library. London: William Heinemann Ltd.

Garde R.J. (1995). *History of Fluvial Hydraulics*. New Delhi: New Age International Ltd.

Newson M. (1992). Land, Water and Development. River Basin Systems and their Sustainable Management. London and New York: Routledge.

Rouse H. and Ince S. (1957). *History of Hydraulics*. New York: Dover Publications Inc.

Shaw E.M. (1994). *Hydrology in Practice*. 3rd edition. London: Chapman and Hall.

Who's Who. (2001). Published by A and C Black, London.

Biographical Sketch

Robert Sellin is Emeritus Professor of Civil Engineering, having taught and carried on research in hydraulics and water resources management at the University of Bristol from 1970 until his retirement in 1997. He graduated in Civil Engineering at Bristol in 1955 and then completed his PhD before working in the Royal Naval Scientific Service. In 1962 he moved to a lectureship in Civil Engineering at the Queens University of Belfast which he held until his return to Bristol. His current professional interests include the behavior of two-stage river channels and their vegetation, and also the hydraulic engineering of the Roman Empire.