Ancient Agricultural Powered-Mills, Part II

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As we saw in the last two issues of *Labyrinth*, agricultural grinding and milling technology may have started off simply with human-powered hand-mills and massive animal-powered "Pompeiian" mills, but that technology soon turned complex with the introduction of mechanized mills powered by nature.

The complex mills of the ancient world, whether powered by water as with the sophisticated "Vitruvian" mills which came into limited use in the first-century Roman world, or by wind as with the complex mills of the ninth-century medieval world, all relied on something at once limitless and yet, for the most part, unpredictable—the use of nature as a labour-saving power source. While we may think of the Romans as great technicians and innovators, they largely borrowed their technologies from other, sometimes much earlier, civilizations such as the ancient Persians and East Indians. As an example, the "noria" or vertical-wheel water-lifting device of the Near East (see *Labyrinth* No. 53) was most likely the inspiration for the later "Vitruvian" water-mill (*Labyrinth* No. 54), since it is evident that the basic design and principle of the latter came from the "noria".

About a century after Vitruvius described the undershot water-wheel grain-mill, Pliny the Elder (first century AD) stated that peasant farmers in rural Italy were using two types of grinding machines to produce flour—a rough mortar and pestle arrangement and the water-wheel (*Natural History*, XVIII.23). Although he does not mention what type of mill was in use at the time, perhaps taking for granted that his reader would know, Pliny undoubtedly was referring to the earlier, more primitive, vertical-shaft mill, which for all intents and purposes was merely a mechanized grinding quern. The Vitruvian water-mill with its complex gearing and horizontal shafts, on the other hand, seems to have been more of an urban instrument developed to meet larger commercial needs. While both have maintained continued use through the ages, by the end of the fourth century AD, the Vitruvian undershot, vertical-wheel design was the mill of choice throughout the Roman Empire. In Europe, at least, its popularity and continued use spread from Rome to Germany, thanks to the barbarian invasions, and from there to northern France and England.

When viewing the vertical-shaft and Vitruvian mills as two distinct types of mills, however, an interesting question arises. As mentioned in the last issue, the more primitive vertical-shaft water-mill for grinding grain requires a mill-race and water chute to supply it with an adequate force of water to turn its horizontal wheel of slanted vanes. Was this mill-race and chute adapted and added to the later Vitruvian undershot water-mill to produce a third type of water-mill, the overshot, where water is directed on top of the vertical wheel (see *Labyrinth* No. 54)? This "new and improved" water-mill was used extensively where river channels with fast flowing water (necessary for the undershot-type) were either not available or not practical to construct.

While the undershot water-mill was described by Vitruvius in the first century BC as mentioned, the idea was largely ignored for some 400 years before it came into common use throughout the later Roman Empire. It seems that it was very difficult for the established millers of the day to leave behind their tried and true methods of grinding grain using animal and slave-power in the cities, especially when such power was so abundant, in favour of water-powered mills at new and often remote sites by constant and swift flowing rivers. Despite the fact that these water-powered mills were far less labour-intensive and, in the long run, cheaper to operate, the new innovation was something that was generally not considered by businessmen of the day as prudent in the later Roman Empire. It was not until the use of slave labour and even animal labour for menial tasks such as grinding grain was no longer considered efficient that water-mills came into common use towards the end of the fourth century AD. Shortly thereafter they were by far the standard mill in use and at times quite ingeniously arranged. So important were the grain mills of urban Rome that in the sixth century AD, General Belisarius ordered undershot water-mills to be built upon moored floating barges in the middle of the Tiber River to foil the siege plans of the Goths in Rome (Procopius, *History*, V.19). It seems that the Gothic invaders threatened to cut off Rome's water supply for milling and thereby cause a massive food shortage for the besieged city and this threat forced Belisarius to devise his ingenious plan to save Rome.

As to the relative and comparative efficiency and output of these various types of powered grain-mills through the ages, the overshot mill was by far the most efficient for the power used, but also came in with the highest initial cost of setup and construction. One of the best examples of this type of complex, both archaeologically and historically, was at Barbegal in southern France, where, around the fourth century AD, eight sets of overshot water-wheels turned highly efficient millstones to produce about three tons of grain flour per hour —a remarkable achievement for an ancient commercial operation (see *Labyrinth* No. 54). Vertical-shaft mills, on the other end of the efficiency scale, remained more of a low-yield, personal production mill for peasants who used it in common within a rural village.

Due to a lack of hard evidence and a precise knowledge of all the gear ratios and millstone sizes involved, it is very difficult to gauge production figures, let alone compare the various milling outputs between the water-driven mills of antiquity and those driven by animals or even humans. Water-mills were able to operate twenty-four hours a day with only minimal human attendance as compared with the animal/human labour-intensive operation of Pompeiian-type mills. This would, at first glance, indicate that the former would have been preferred throughout antiquity, and yet for the most part Greece and Rome relied largely on their slaves as power sources and therefore generally ignored all other sources of power. It is true, however, that the rivers which powered these undershot mills were at the mercy of natural seasonal variations, whereas animals and humans were always readily available.

For all of this technology, though, what is ultimately most important is the end result—the quality of the flour produced by all these different types of hand and powered mills. Even at the best of times, the hand-mills, animal-mills and water-mills of Roman times probably produced only a coarse flour meal which still had to be sieved by hand to remove all of the larger impurities and produce a finer flour suitable for cooking and baking.

All of this mechanization and innovation led to great strides in later industrialization but this is where we will leave the production and processing of grain and flour in favour of some of the other staples necessary for human existence and the enjoyment of life: wine and oil.