efficiency is therefore much lower than an overshot wheel, which acts under the weight of water in its buckets (like a lever), and therefore benefits from the head as well as quantity of water. The longer the overshot wheel can hold the water before dumping, the greater the lever effect. Prior to the Civil War, almost all water wheels were wooden. Buckets, which held the water to near the bottom of the wheel, were difficult to build. Therefore, the efficiencies of the old wooden overshot wheels were usually around 50-65% at most. After Fitz and other companies began building
metal wheels, efficiencies improved due to better bucket design and lower-friction bearings. The metal wheels were also lighter than their oak counterparts, and ran smoother. Fitz claimed efficiencies as high as 95% based on university tests, but I'm sure this was more advertising hype than reality. When a mill owner bought a Fitz wheel and began powering his equipment, my guess would be the true efficiency was probably closer to 85% in the ideal situation. This was about comparable to the water turbines of the era. If a decision was to be made between an undershot or overshot water wheel for a particular site, the horsepower requirements for the shafting and machinery to be driven were ascertained (most manufacturers supplied this information). The stream horsepower could then be multiplied by an appropriate efficiency factor for either wheel design. If wood was to be the building material, this factor should be a maximum of about 35% for undershot wheels and 65% for overshot. The result could be compared to the machinery requirements to determine which design to choose. For example, assume stream horsepower was 50, and machinery required 25 horsepower. Then an efficiency of 50% could be tolerated from the water wheel. This would indicate an overshot wheel. Then you get into bucket design, optimum number of buckets, width of the wheel to accommodate a given flow of water, etc., etc. You might want to read Terry Reynold's book entitled Stronger Than a Hundred Men: A History of the Vertical Water Wheel, Johns Hopkins University Press 1983. SPOOM sells reproductions of some old Fitz bulletins, too, which touch on some of this. Oliver Evans' book is most interesting also, but uses archaic terminology.

Keyword **Waterwheel**

Title **Waterwheel efficiencies**

Author **Dr. John Lovett Jr.**

Waterwheel efficiencies:
Mechanical, or working, efficiency, is simply the ratio of the power a water wheel can deliver to the power of the water supplied to it. This can never be 100% due to friction and other losses. In the days of water wheel design and construction, it was customary to measure flow and head of water in the stream that was to supply the wheel in order to judge an appropriate size for the wheel, and estimate the expected horsepower. Stream flow was measured by installing a weir in a small creek, or by a float method in a larger one. Head, or total drop of water available, was measured with a surveyor's level or transit. The full horsepower of the stream could then be calculated by multiplying the number of cubic feet of water flowing per minute by the head in feet, then multiplying by the weight in pounds of one cubic foot of water (62.33), then dividing this product by 33,000. Usually only a portion of this water was actually delivered to the wheel, through a race or flume, so sometimes a percentage was multiplied by the horsepower result based on the estimated amount of water to be taken for driving the water wheel. Particularly in the nineteenth and early twentieth centuries, several methods were developed for applying loads to waterwheels to test their efficiencies under simulated operating conditions. One of the most common devices so used was the Prony brake. It applied a load to either the water wheel's main axle or a countershaft and provided a result, which could be compared to the theoretical horsepower of the stream. By dividing the stream horsepower into the working horsepower of the wheel (as measured by the loading device), an efficiency value was thus obtained. Without going into the theory and equations for energy, suffice it to say that the undershot wheel is driven by the velocity of water striking its paddles or blades, with the head of water having little bearing on its power output. Its