Table 9.3
Transmission efficiencies for chain drives

Driver rpm Power (W)	70 100	60 100	50 100	60 150	60 175
Calculated chain tension (N)	130	151	182	227	265
Number of teeth, driver-driven					
52–11	88.7	91.1	92.5	94.6	95.5
52–15	90.4	92.3	94.7	96.2	97.5
52–21	92.0	93.8	95.2	97.4	98.2

Source: Data from Spicer et al. 1999.

Transmission efficiencies

A full knowledge of the losses occurring in present bicycle transmissions would focus our attention on whether there are problems and, if so, on how to correct them. Unfortunately, there is presently no consensus. We will therefore report data with cautions and comments.

Ron Shepherd (1990) has stated that the efficiency of chain transmissions, including derailleurs, is normally over 99 percent. Spicer et al. (1999), on the other hand, measured efficiencies down to 88 percent on a clean, as-new derailleur system. Their most-significant findings are given in table 9.3. They point out the following.

1. Transmission efficiency decreases as the size of the rear sprocket is reduced.
2. Efficiency diminishes as the amount of torque transferred (or chain tension) is decreased.
3. The maximum efficiency attained is at relatively high power (175 W) and low pedal rpm (60) and in the lowest gear (meaning the largest-diameter rear sprocket, with twenty-one teeth) and is just over 98 percent.
4. The additional losses because of chain offset (the two sprockets not being in line) are negligible.
5. The type of lubrication, or even whether there is lubricant present, has almost no effect on efficiency (see tables 9.4 and 9.5).

These results, which in many cases contradict popular wisdom, were reviewed by Kyle (2000), who had recently himself supervised a similar proprietary study. He confirmed the general findings and accuracy. His own study in collaboration with Berto (Kyle and Berto 2001) has extended the data given here and is recommended for more detailed study.

Table 9.4
Efficiencies of new, clean, lubricated chain drives

		Three-speed hub			Six-speed derailleur		
Power (W)	Single-speed	Low	Direct	High	24T COG	19T COG	13T COG
50	96.0	90.6	93.4	87.3	94.2	94.1	92.1
100	97.3	92.8	95.7	90.9	96.2	96.4	94.9
200	98.1	94.0	96.9	92.9	97.4	97.6	96.9
400	99.0	95.0	97.9	93.9	98.1	98.4	97.8

Source: From Keller 1983 and Fichtel & Sachs A.G. 1987.

Table 9.5
Efficiencies of shaft drive and of clean and rusty chains

	Shaft drive + three-speed hub gear			Used chain	
Power (W)	Low	Direct	Normal	8,000 km, no rust, lubricated	7,000 km, rusty, dry
50	79.2	82.2	77.3		
100	84.8	88.3	83.3	94–96	88
200	86.6	90.0	85.1	97–98	93

Source: From Keller 1983, 71–75.

Other data from various sources (Wilson 1999) are given in tables 9.6–9.9. The highest efficiencies for the hub gears examined are lower than the highest efficiencies for the derailleur gears considered. However, most of these data were taken in static force tests as described by Cameron (1998), which are not as satisfying as power-input and -output data. Nevertheless, the results confirmed many of the trends of Spicer et al. 1999. Whitt also used static measurements to produce graphical data given in figure 11.16 of the second edition of this book and quoted Thom, Lund, and Todd 1956, again following similar trends.

Measurements of transmission efficiency are difficult to make accurately, because they involve subtracting two imperfectly known large quantities (input and output power) to find a much smaller quantity. Average torques must be known to within 0.1 percent to determine losses with accuracy. The conventional "back-to-back," "recirculating," or "four-square" method, involving two loops of chain each driving the other, is dubious when the sprocket ratio differs from unity, because the efficiencies