From da Vinci to Recumbent… Velocity and the Velocipede

By William P. Ancker

The bicycle is a curious vehicle," American champion cyclist John Howard once remarked. "Its passenger is its engine." These curious vehicles we call bikes occupy a unique place in the history of technology. Modern bicycles, based on technological innovations from the late 19th century, remain the most efficient means of human transportation ever invented.

Those same innovations had a pivotal influence on other forms of transportation. Manufacturing improvements from the bicycle industry contributed to the development of the automobile and the airplane. In addition, the bicycle had a profound social impact in countries where bicycling began by emancipating women from their tight bone corsets and long heavy dresses. The positive impact of the bicycle continues today as pedaling technology improves and more people pedal.

The bicycle is a marvel of fuel efficiency. In terms of energy expended and distance covered, traveling by bicycle is far more economical than traveling by horse, motorcycle, or car, and even more economical than walking or running. Of course, the fuel of bicycle riders is the food they eat. An average cyclist can cover approximately five kilometers on 100 calories, the number of calories in a banana. One hundred calories' worth of gasoline could take a lightweight car only 100 meters. In addition to being incredibly fuel efficient, bicycles are environmentally friendly in other ways. For example, they generate no air or noise pollution and do not require huge paved roads or parking lots.

Cycling is not only good for the environment; it's good for the rider. Riding a bike can provide an excellent physical workout. It exercises the major muscle groups (back and legs), increases cardiovascular fitness (heart and lungs), and improves blood circulation. It can provide these health benefits without intense straining or profuse sweating, and without the pounding of joints and risk of injury found in sports such as tennis, basketball, soccer, and running. The development of comfortable and lightweight bicycle helmets over the past 20 years has made the sport even safer.

History

The concept of a human-powered, two-wheel vehicle is centuries old, but as Perry (1995) points out, the technology required to produce a bicycle-like device did not appear until the 19th century. The notebooks of Leonardo da Vinci show that he (or an assistant of his) drew a bicycle-like device in 1493. However, historians say the true "father of the bicycle" is the German inventor Karl von Drais. In 1818 he patented a simple vehicle consisting of a wooden beam with two wheels attached and a crude steering mechanism. The rider sat on a cushion on the beam and propelled himself by pushing with his feet along the ground.

The development of the modern bicycle is a fascinating chapter in the history of technology. The first key innovation was direct drive propulsion, for that is when the passenger became an engine. Pedals and cranks were attached to the hub of the front wheel so the rider could sit up and propel himself. The front wheel was much larger than the rear wheel, and photographs from the 1870s show "high wheeler" bicycles that are almost as tall as the riders. Although the vehicles were unwieldy, even dangerous, to ride because of the height of the rider, they were popular with men. Cycling clubs were organized and the sport of bicycle racing began.

The next two major innovations, occurring in rapid succession, gave us the modern bicycle. The direct drive arrangement of the high wheeler was replaced by a chain drive mechanism attached to the rear wheel. This change enabled bike designers to use wheels of equal diameter. James Starley established the Rover Cycle Company in England, which incorporated these features in the new "safety" bikes of the mid-1880s.

The second major innovation was more comfortable tires. The Scottish veterinarian John Dunlop is generally credited with the invention of the rubber pneumatic tire in the late 1880s. Before the air-filled pneumatic tire, bicycle tires were leather or solid rubber and offered little shock absorption. The jolting ride of the solid tires (made worse by the condition of roads in that era) gave some early bicycles the nickname "bone-shakers." With pressurized tires and a chain drive mechanism, the golden era of the bicycle began.

Impact

As the bicycle became safer and more comfortable, women—at least the more daring women—finally had the chance to experience the enjoyment and freedom of pedaling a bike. At that time in many places, women were generally not permitted to perform strenuous exercise out of a mistaken fear that the female constitution was too frail. Fortunately, the bicycle helped change that notion, and as more women rode, they demanded lighter, looser clothing that permitted greater freedom of movement. The loose ankle-length trousers worn under a short skirt, called *bloomers*, became popular among women who rode bicycles. In 1896 the American suffragist Susan B. Anthony said, "I think [bicycling] has done more to emancipate women than anything else in the world. It gives women a feeling of freedom and self-reliance."

Although it is an absurdly simple mode of travel when compared to the luxury of a long limousine or the supersonic speed of the Concorde, the humble bicycle had a key role in the early days of the automobile and airplane. In 1885–1886, German engineers Gottlieb Daimler and Karl Benz built motorized bicycles and tricycles, respectively, business pursuits that would eventually lead them into automobile manufacturing. Dodge (1996:152) lists the following innovations of the bicycle industry that were essential in the construction of automobiles: lightweight steel tubing, wire spokes, adjustable ball bearings, uniform interchangeable parts, and assembly-line mass production. Americans Wilbur and Orville Wright, who built and flew the world’s first motor-powered airplane in 1903, began repairing bicycles in 1892 and manufacturing them in 1896.

Modern technology

Two modern-day innovations in bicycle design are the recumbent bike and the use of aerodynamic equipment. Both have made radical changes in the position of the rider. As its name suggests, a recumbent puts the rider in a reclining, more horizontal position than a typical bicycle. Incidentally, this reclining position makes the rider and machine more aerodynamic. Aerodynamic equipment came out of the sport of bicycle racing as riders and their sponsors sought to improve pedaling efficiency and therefore increase speed. The greatest resistance a bike rider encounters is air resistance.

This is obvious to anyone riding into a head wind, but air resistance is present even when no wind is blowing into the rider's face. One way to increase speed is to enable the rider and bike to move through air faster, so equipment manufacturers have created exotic-looking wheels, helmets, and other components that create less air turbulence.

The greatest cycling innovation in recent years is the creation of the mountain bike. Designed for steep dirt trails, it has wide knobby tires, low gears, and front and rear suspension. Since the early days of mountain biking in northern California and Colorado in the late 1970s, when a handful of riders rebuilt old bikes to make them more suitable for off-road riding, mountain bikes have become a multi-million-dollar industry within an industry. In many shops in the United States, mountain bikes outsell the skinny-tire bicycles intended for paved roads. An entirely new branch of bicycle racing evolved quickly. It features cross-country races on dirt tracks and trails, somewhat similar to motocross, as well as downhill races similar to alpine skiing. Already the sport of mountain biking is included in the Olympic games.

As the American playwright Stewart Parker observed, "The bicycle was the last advance in technology everybody understands. Anybody who can ride one can understand how it works." Perhaps its simplicity of design is what makes the bicycle such a practical and popular means of transportation in many countries around the world. As bicycle technology advanced, the vehicles themselves appeared in more countries around the world. What began as a novelty for the wealthy in northern Europe almost 200 years ago has become a universal and delightful means of transportation.

Bicycle Racing and Technology

One of the most revered titles in bicycle racing is for the longest distance ridden in one hour. The competition for the hour record is held on an indoor wooden cycling track, where obstacles such as windy weather and rough pavement are minimized and the solo cyclist can focus on pedaling lap after lap for 60 minutes.

The Belgian rider Eddy Merckx, the greatest bicycle racer in the history of the sport, set a world record of almost 50 kilometers on a track in Mexico City in October 1972. His record stood for 12 years, until the Italian rider Francesco Moser broke the record by riding over 51 km on a bicycle that utilized aerodynamic technology unavailable at the time Merckx rode. Then in succession, a number of elite riders attacked the hour record, each using newer and more

efficient aerodynamic equipment. By 1996, British rider Chris Boardman had gone 56.375 km in an hour. (See the chart below.)

In 1997, the Union Cycliste Internationale (UCI), the organization that governs bicycle racing worldwide, decided that technology had gone too far and was giving riders an unfair technological advantage that overshadowed the athletic feat of setting the hour record. The UCI reinstated the 1972 distance of Merckx as the official world record. The longer distances ridden by later riders on high-tech bicycles would no longer be counted.

Before retiring from the sport, Boardman decided to make one more attempt at the hour record, only this time adopting the new rules of the UCI, which required using the old technology available in 1972! The day before his final, "low-tech" attempt on the record, Boardman commented, "If nothing else, tomorrow will prove how good Eddy Merckx was." Boardman was too modest. He set a new record by 10 meters in October 2000—exactly 28 years and 2 days after Merckx had set the benchmark record.

By any other name...

Shakespeare wrote in Romeo and Juliet, "What's in a name? That which we call a rose, By any other name would smell as sweet." He was speaking of the nature of something being unchanged by the name which it is given. The word *bicycle*, whose etymology is French, has been incorporated into other languages worldwide. In many instances one can still find some vestigial root of the original word. Yet other cultures have formed entirely new words to describe a "vehicle with two wheels in tandem, usually propelled by pedals connected to the rear wheel by a chain, and having a saddle-like seat and handlebars for steering" according to *Random House Webster's Unabridged Dictionary*. What do you call it? Write and let us know!

Albanian	biçikletë
Arabic	bisiklaat, bisiklaataat
Australian	bush bike
Cameroon	pating bamileke
Chinese	zixingche, danche, jiaotache
Czech	bicikl, kolo
Danish	cykel, liggecykel, sofacykel
Dutch	fiets, loopfiets, tweewieler, hoge bi, dreiwielfiets, ligfiets
English	bicycle, bike, cycle, trike, tricycle, three-wheeler, high-wheeler, penny farthing (high wheeler), tandem (bicycle built for two), rickshaw, pedicab (passenger cycles)
Esperanto	bicikleta
Flemish	fiets, rijwiel, schrijwiel, trapwiel, vlosse-peerd, loopfiets
French	vélo, vélocipéde, bicyclette, cyclisme, bécane
Gaelic	da'chasach, ceffyl, heaarn, deurod
German	fahrrad, rad, radl, dreirad, zweirad, hochrad, klapprad, liegerad, sesselrad, kurzfahrrad, rikscha

Hawaiian	ka’a paikikala
Hungarian	kerékpar
Indonesian	sepéda, bersepéda
Irish	rothar, gearran, iarainn
Italian	bici, bicicletta, due ruote, monociclo, triciclo, dupletta, michaudina
Japanese	ji-ten-sha
Kikuya	baithikiri, maithikiri, m˜ubbria
Korean	cacénk
Latvian	divritenis, ritenot
Lithuanian	divratis
Lingua Franca	bersable, bercagle
Norwegian	bicykkel, sykle, sykkel, velosipéd
Polish	bïka, rower
Portuguese	bicicleta
Rumanian	bicícleta
Russian	velociped
Serbo-Croat	tocak, velosiped, bicikl, jahati
Slovak	bicykel, dvojkolo
Spanish	bicicleta, bici, chiba
Swahili	baisikeli, boda boda (bike taxi)
Swedish	cykel, bysicles, bicykel, velociped
Philippino	bisikleta
Tahitian	pere o’o taatahi
Turkish	bisiklet, bisikletle, gitmek
Ukrainian	velociped

(This list was adapted from Perry 1995).

Web sites of interest

These are a few of the Web sites regarding the sport and science of cycling.

http:// www.exploratorium.edu/cycling/
This Web site explores the science of cycling. It has information on wheels, drives and gears, frames and materials, brakes, aerodynamics, and human power.

http:// www.pedalinghistory.com/
This is the Web site of the Pedaling History Bicycle Museum in Orchard Park, New York, the largest bicycle museum in the United States.

http:// www.cyclingnews.com/
This Web site features up-to-date news and archives of bicycle racing around the world. It lists results, gives daily news summaries, and includes letters from cyclists interested in racing issues.

http:// www.uci.ch/english/default.htm
This is the Web site of the Union Cycliste Internationale. It has news of races and related events. There is also a French version of the UCI site.

http:// www.bicyclinginfo.com/
This is the Web site of the Pedestrian and Bicycle Information Center. The site has something of interest for everyone who cares about bicycling, from riders and community leaders to city planners and government officials.

http:// www.ihpva.org/
This is the Web site of the International Human Powered Vehicle Association, an international network of national associations dedicated to promoting improvement and innovation in the use of human power. IHPVA also publishes a technical journal called Human Power.

http:// www.ibike.org/
The International Bike Fund is a non-governmental, nonprofit organization that advocates non-motorized urban planning, sustainable transport, and international understanding through cycling.

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