THE CONQUEST OF FRICTION

The wheel is often described as the most significant invention of all time. Actually, that is not literally the case. The real innovation was putting the axle and the bearing into the large round carrier.

There is ancient evidence of the use of round surfaces to reduce the effort needed to move heavy objects. The Egyptians, for example, used logs. Bearings used with early wheels and axles were of plain form (journal bearings), in which a journal or shaft is fitted with a close clearance in a sleeve.

The Romans made rudimentary use of anti-friction-type ball bearings around the time of Christ. The remains of a Roman ship in Lake Nemi are of great interest in this regard, as three basic forms of rolling-element bearings with ball, cylindrical, and tapered rollers were found, although their use is unclear.

During the Renaissance, Leonardo da Vinci sketched an anti-friction bearing, but its intended use is unknown. As the Industrial Revolution evolved, during the 18th century we went from sailing ships to steam power and bearings began to appear in great numbers. However, they, too, were journal rather than anti-friction type bearings.

One of the thorniest problems hindering man’s mobility up through the 18th century was known as the longitude problem. Lacking the ability to measure longitude, sailors literally became lost at sea once they lost sight of land. John Harrison solved this problem with a seaworthy clock called the chronometer. One of his early prototypes used a caged ball bearing, but in his quest to miniaturize the chronometer, he replaced this early use of an anti-friction bearing with a tiny jeweled journal bearing.

The beginning of the anti-friction bearing industry (that is, of bearings with rolling elements) as we know it started in the early 1880s when Friedrich Fischer in Germany developed a way to manufacture precision spherical balls economically in high volumes and gave birth to Fischer AG. The 19th century also brought us railroads, electrical devices, telegraphs, electrical power, the telephone, and the bicycle.

As is often the case, a manufacturing breakthrough is often the key to a successful product launch. First used in bicycles, ball bearings were a well-developed technology when the auto industry was launched at the turn of the 20th century. The auto industry expanded rapidly. Motor vehicle registration in the United States increased from about 1,000 in 1898 to 10,000 in 1900. By 1906, more than 100,000 cars were registered. The million mark was exceeded by 1913, after Henry Ford revolutionized the auto industry by introducing the assembly line and interchangeable parts, thus making the car affordable for the common man. By 1922, 10 million cars were registered in the United States.

Today it is estimated that the world has an automobile population of approximately 800 million. The auto industry generates the need for better roads and machine tools. It's an endless cycle for the growth and creation of jobs.

But Ford also saw the opportunity to apply auto technology to farming with the creation of the Fordson tractor. At the start of the 20th century, a U.S. farmer fed 2.5 people. Today, that farmer feeds more than 100 Americans plus 32 people in other countries. This revolution has released the rest of the population to pursue the intellectual, cultural, and social development that has resulted in our modern society. Agricultural mechanization, like manufacturing, can be viewed as an enabling technology that made possible the other advances of the 20th century.

The first half of the century also brought us vacuum tubes and radios, airplanes, nylon, and antibiotics. The second half saw a revolution in electronic devices that significantly enhanced our ability in communications and improved productivity in our service and manufacturing industries. During the century, air travel became affordable for the masses and we put a man on the moon in basically one decade of hard work in the 1960s.

Space age technology led to communication satellites, mobile phones, the Internet, and a revolution in the computer industry. In 1985, an IBM mainframe cost $3 mil-
Early technology for producing bearings: The factory's grinders were driven by belt and pulley arrangements connected to a single power source.
lion. Today a $1,500 home computer can do the same work 100 times faster. Complex composite materials were developed and we finished the century with the launch of genetic research. This is creating the platform for great strides in medical science and the hope to extend people’s life spans by a significant degree.

The pace of change has also been phenomenal. It took us 5,000 years to go from the invention of the simple wheel to railroads, but within a single life span, 66 years, we went from man’s first flight to man’s first walk on the moon.

Enhanced mobility and communications have changed for the better the world in which we live. Solutions for reducing friction are at the root of societal progress. Not only have improved anti-friction bearings played a significant role in the enhanced mobility of society in the last century, but the bearing industry has likewise benefited from the new technology as well.

The performance of bearings is greatly influenced by the quality and performance specifications of the steel used to make the bearings and the precision of the bearing’s internal geometry. High-performance bearings should have internal tolerances that are consistently controlled to approximately 1/100 of the diameter of a human hair (internal bearing tolerance can be controlled to 1 micrometer or better).

In the 1960s, it was realized that space flight would not be possible without enhanced fundamental knowledge of anti-friction devices in the space environment of a vacuum. During this time frame, A. N. Grubin of the Central Scientific Research Institute for Technology and Mechanical Engineering in Moscow and two Britons, D. Dowson of the University of Leeds and G.R. Higginson at the Royal Military College of Science in Shrivenham, developed an elasto-hydro-dynamic lubrication theory that explained the mechanism of why bearings and gears worked.

As the name of the theory implies, once the elastic deformation of the contacting components was taken into consideration, they were able to account for the thicker film that developed between the rolling elements and the races. Furthermore, the tremendous pressure that results in the contact area caused the lubricant to change to a pseudo-solid equal to the consistency of road asphalt, thus avoiding metal-to-metal contact of the rolling elements and the raceways.

Developments in the electronic field gave the bearing industry the tools to verify these theories, to understand the fundamentals of machine tool dynamics to improve...
As a publicity stunt in Chicago in 1930, three women in high-heeled shoes hauled a 323-ton locomotive made for Timken and rolling on company bearings.

grinding precision, and to develop ultrasonic equipment to improve the quality and the performance specifications of steel.

Then, in the early 1970s, Intel invented the microprocessor and consistent precision control of machine tools, and the steel-making process became an economic reality. The end result is that, during the last 20 years, bearings less than 100 mm in bore size have increased in life by a factor of 10 times and bearings greater than 200 mm in bore size by a factor of 20 times. In turn, increased mechanical precision made possible the manufacture of ever-smaller and more refined electronic devices.

However, bearings are only part of a mechanical system. In transmissions and transaxles, gear design and selection are critical considerations. Actually, gears are greater design challenges than are bearings, as they not only are subject to contact fatigue, but bending fatigue and wear as well. So, in the design of a transmission or transaxle, one must consider the total system. Bearings, gears, lubricants, seals, and housings are critical to the success of a design.

By combining the latest computer design tools with the improved bearing and gear performance developed during the last 20 years, transmissions have been upgraded to transmit three times the horsepower in the same space.

Henry Timken, inventor of the modern tapered roller bearing, is quoted as saying, “The man who could devise something that would reduce friction fundamentally would achieve something of real value to the world.”

Man’s ability to overcome friction has created a better life for an ever-increasing population. Awareness of the contrasts between the communist and capitalist economic systems created by enhanced mobility and improved communication certainly had a lot to do with the collapse of the Soviet Union without a major war. We’ve seen a new socioeconomic globalization model develop, resulting in the rise of market capitalism around the world. Communications and mobility have lowered commercial and cultural barriers between nations. Urban per-capita income in China has increased tenfold since the reforms in 1978.

People who see their lives get better with each passing year don’t want war. Recent events in Iraq, North Korea, and the “war on terror” have and will hopefully come to positive conclusions from instant global communications and man’s improved mobility. It is difficult to have hidden tyranny in a world that has cell phones and the Internet. It is a world in which we can develop a better understanding of each other’s cultures, and political, religious, and socioeconomic systems, and so avoid conflict among ourselves.

That would be man’s true conquest of friction: through improved mobility and communications to create a prosperous world that, for the first time in history, could be at peace with itself.