
THE TECHNOLOGICAL IMPERATIVE

BY EDWARD TENNER

The road from Princeton, New Jersey, to Philadelphia passes the handsome iron-fenced grounds of the Lawrenceville School, a private institution known not only for its high academic standards but also for its ample resources. Its gracious campus could easily house a substantial liberal arts college; in the summer, its auditorium does justice to professional opera productions. Though Lawrenceville's flush financial condition is news to no one, I was still surprised when driving by one day last autumn to see how grandly the school pursued the game of football. Looming over a practice field just beyond the fence was a railed platform suspended by two tonglike metal frameworks over a wheeled base the size of a small car. Standing atop this elaborate machine was a man with a video camera recording the team's practice session 10 or more feet below. Even here, a world away from the NCAA Division I, technology was literally raising its head—vivid evidence of the lengthening reach of the apparatus of professionalism.

It is true that coaches have been analyzing film since the early days of moving pictures, that video cameras now start at only a few hundred dollars (though this one appeared to be a bigger and much costlier professional model), and that mobile lifts probably have some value for building and grounds crews as well as for the athletic

department. And one would have to be Rip Van Winkle not to know that schools and colleges are working harder at sport and spending big money on new athletic technology. Only a few hundred yards from my apartment, on the banks of Lake Carnegie, Princeton rowing crews practice during New Jersey's often inclement weather in an enclosed tank. Across the road, a field of artificial turf is being installed for the lacrosse team at a cost of more than \$1 million. (Competing teams were all using them, the coaches pointed out, and a generous alumnus picked up the bill.)

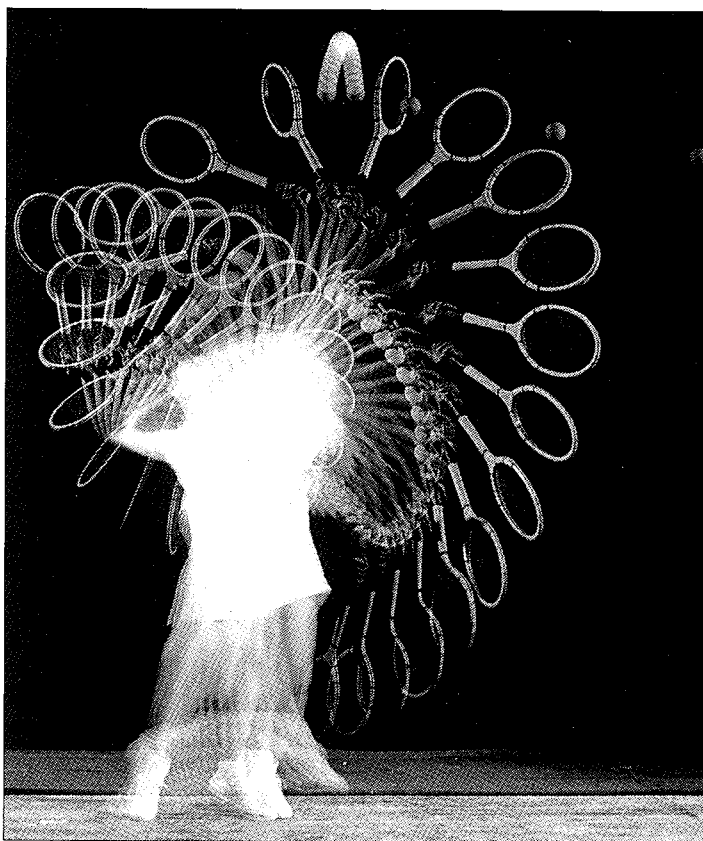
Yet the Lawrenceville image stayed with me: a portable tower with an all-seeing eye, a monument to the interpenetration of sport and engineering. It is a relationship that has improved athletic performance and challenged physicists and designers. It has often, though not always, made sports safer. It has also threatened the traditional virtues of athletic life. It is often said that the infiltration of big money, especially in such high-profile intercollegiate sports as football and basketball, is killing off the amateur ideal. But nothing is doing more to undermine the distinction between amateur and professional competition than the rise of sports technology—including not only athletic gear, but training and conditioning techniques and professional management—and its spread to all levels of sport.

It is not incidental that I spotted the

mechanical tower at a school that was the setting for Owen Johnson's famous turn-of-the-century Lawrenceville stories. In many ways, the stories and the school epitomized the older ideal of gentlemanly amateurism in sports. Athletics in such corners of American life, as in similar British ones, shared the antiprofessional outlook of the old humanities curriculum. "Just as the classics trained your mind for anything, games trained mind, character and body for anything," Jonathan Gathorne-Hardy notes in *The Old School Tie* (1978).

This gentlemanly model of sport was not at all inimical to training, but it put the emphasis on other aspects of competition. In one of Johnson's episodes, Dink Stover, the hero of the series, learns "that the scientific application of his one hundred and thirty-eight pounds, well-timed, was sufficient to counterbalance the disadvantage in weight." Yet Dink succeeds on the football field not by studying videotapes but by developing his character and his innate intelligence. In a big game, the opposing Andover 11 play "with a precision and machinelike rush that the red-and-black Lawrenceville team did not have," writes Johnson, leaving no room for mistaking his own view of the machine. At half time it is the teenaged team captain, not the adult coach, who harangues the Lawrenceville squad, urging them to hold back the Andover line. Only then does the adult coach, the professional, give brief advice to each young man. Inspired by his teammates' comradeship and spirit, and laying an old grudge against one of them

aside, Dink goes on to score the winning touchdown. In this Lawrenceville of yore, it was the athlete's desire for honor and the esteem of his peers that mattered most, not his hunger for athletic scholarships or his



The scientific study of motion in sport was born a century ago. Today, even casual players in many sports have their serves and swings analyzed.

hopes for a career in sports. In Dink Stover's world, spirit and character always triumphed over regimented efficiency.

The trouble, of course, was that in real life they neither could nor did. As sports historian Ronald A. Smith shows in *Sports and Freedom* (1988), college teams born as outlets of youthful rebellion against faculty paternalism and pedantry early in the 19th century began hiring professional coaches soon after the Civil War. On college playing fields,

at least, plucky amateurs such as Stover and his friends found themselves losing to teams that practiced under close adult scrutiny. As expenses and competition both grew toward the end of the century, colleges began to bring sports under their administrative control. The coach began his ascent from student-paid specialist to college-paid star. It stretches the point only a bit to note that this rise roughly coincided with that of the professional manager in the period's emerging large corporations. And unlike business executives, some early star coaches could have it both ways: the University of Chicago's first football coach, Amos Alonzo Stagg, not only received the executive-level salary of \$2,500 when he was hired in 1891 but was made a tenured associate professor. (It was only fair that Stagg was given faculty standing, since he made the kind of original contributions—such as the end-around run and the man in motion—for which professors of any science get tenure.) President William Rainey Harper charged Stagg to send forth teams that would “knock out all the colleges.”

The decline of amateurism was not the product of technological forces alone. The ideal of athletic heroism began its downward course after World War I, with its brutal deflation of gallant rhetoric. Some of the real heroes who had survived the ordeal of war felt out of place in its aftermath. Princeton hockey star and World War I ace Hobey Baker was miserable as a bond salesman (and club player) after the war. He died under mysterious circumstances, crashing a military plane he had borrowed. Baker came of age a generation after the creator of Dink Stover, but he was one of the last gentleman paragons of sport. At Baker's Princeton, the bronze statue called “The Christian Stu-

dent,” a memorial to a high-minded football captain named Earl Dodge who had died of typhoid in his twenties, had stood unmolested for decades. By the 1920s, this statue of a handsome youth in a turtleneck football uniform, draped in academic robes and laden with books, had become a provocation. Undergraduates vandalized and travestied it so often that it was finally removed to the Massachusetts museum of sculptor Daniel Chester French. It was not athletics that had declined but heroism. In its place there was instead, for coaches as much as for athletes, stardom.

The decline of the heroic ideal is reflected in the history of protective technology. Football players and other athletes before World War I could have used much sturdier helmets and pads than they did, but they declined to do so for the same reason that professional boxers today (unlike their amateur counterparts) still do not wear headgear: spectators would have considered such protection unmanly. Indeed, early baseball gloves were dyed a flesh color in order to make it less obvious that players were not fielding the ball barehanded. In the late 20th century, conspicuous exposure to risk has become positively unfashionable except in a few events, such as downhill skiing and automobile racing. Athletes today do push the limits of protective technologies to gain an edge. Helmeted batters crowd the plate; linebackers and linemen risk paralysis and death by illegally “spearing” their foes with their helmets. Stronger ropes, lighter gear, and spring-loaded cams have encouraged mountain climbers to attempt previously impossible routes. But the point holds: few men and women still glory in doing without available protection, as Reinhold Messner and Peter Habeler did in 1978 when they climbed

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Mount Everest without supplemental oxygen. A small number of climbers have emulated them, but scores of others have littered the mountain with empty oxygen canisters.

Technological change may not have been directly responsible for the decline of the heroic ideal, but it was the driving force behind the new model of sport that challenged and ultimately replaced it. This new model envisioned sport as a higher craft, assisted by science and technol-

pecially after World War I. He quotes a French athlete's wish in the 1920s that his daughter would "one day recite the litany not of our battles but of our records, more beautiful than the labors of Hercules."

What happened to sport was part of a broader movement to rationalize physical performance that had its origins in workplace time-and-motion study pioneered in the United



Athletes in ancient Greece often resorted to special diets, coaching, and other aids in attempts to improve performance. In this 6th century B.C. vase painting, a coach instructs two long jumpers.

ogy, frankly devoted to record setting and winning. In this new world of sport, excellence was seen not as something that grows from within, but as something shaped by endless practice, refinement of technique, and analysis. Achievements were registered not in the respect of teammates and peers but in box scores and record books. An important source of this emerging perspective, according to Allen Guttman of Amherst College, was the rise of quantification and record keeping, es-

States by the engineer Frederick W. Taylor (1856–1915). Analyzing the task, the tools, and the motions of factory workers, Taylor created what he called a new kind of "scientific management." By breaking down each activity into its component parts and analyzing each motion, Taylor believed he could optimize the worker's efforts and vastly improve performance on the job.

Scientific studies of athletic performance, animal motion, and industrial pro-

duction took giant steps together in the laboratory of Étienne-Jules Marey (1830–1906), a brilliant physiologist who held a chair of “natural history of organized bodies” at the Collège de France. Anson Rabinbach’s *Human Motor* (1990) presents Marey’s work in its scientific and social milieu. Marey developed an ingenious system of stop-motion photography that resolved action into microscopic increments of equal time. Sport was one of his chief subjects, and his books containing ingenious visual representations of motions over time in fencing matches and other activities were a sensation. Marey and his American counterpart, the photographer Eadweard Muybridge, probably enjoyed their greatest fame for settling the old sporting question of whether all four legs of a galloping horse are ever off the ground at the same time. (They are.)

Taylorist methods appeared in American athletics as early as the first years of the 20th century, and they increased the emphasis on coaching (professional management) and technical specialists. Ronald Smith notes that in 1905 and ’06 the young Harvard football coach William Reid, Jr., studied photographs of punting to determine an optimal style and then trained the Crimson’s kickers accordingly. Reid also began to experiment with new equipment designs. And he pioneered the practice of intensive scouting, traveling around the country to recruit exceptional players. Reid even kept a file card on every one of Harvard’s 4,000 students to identify the best prospects for each position on the team. After World War I, systematic study and professional coaching spread to more and more sports. As early as the 1920s James Naismith, the inventor of basketball, deplored the serious coaching that had transformed his sport.

The cult of the coach has become one of the leading features of late-20th-century sport. In certain professional sports, such as tennis, the coach enjoys a status akin to that of a guru, and in team sports the coach (or

rather the coaching *staff*) functions not only as a technical specialist and master mechanic of the sport’s techniques but as a master planner and field marshal—in a word, the team’s brain. How many professional quarterbacks today are allowed to call the plays for their team? And now pro football is experimenting with radio communications between the sideline and the playing field. The rise of the omniscient coach is another one of the forces working to erode the distinction between amateur and professional sports. Not only are advanced training techniques and other methods being disseminated down to the lowest levels of many sports, but coaches themselves move freely between the pro and amateur ranks. And thanks to summer training camps and other special arrangements, youngsters who show promise in some sports are now exposed to the influence of highly trained coaches before they reach their teen years.

If today’s superstar coaches are the heirs of William Reid, the era’s sports scientists are direct descendants of Marey and Taylor. Taylorism in industry has largely run its course, long since superseded by other theories of management. The scientific study of time and motion still matters in American industry, and even more in Japan. But the frontier appears to have shifted from maximizing physical performance to minimizing the new injuries of the postindustrial age, such as carpal tunnel syndrome, an affliction of constant computer users. Now it is the software developer who makes workers more productive. But the early-20th-century dream of the worker as a human motor, operating at top efficiency and approaching a theoretical minimum of fatigue, remains very much alive in sport. Records continue to fall. No one can predict the limits of human performance. This excitement has attracted a striking number of leading scientists and engineers to sport. The physicist Howard Brody

has published a tennis handbook; the engineer Enoch Durbin has designed a revolutionary tennis racket bearing his name; another engineer, Thomas McMahon, has developed "tuned" tracks with optimum springiness that help athletes set running records; another physicist-author, John Adair, consults on scientific questions for baseball's National League. Visiting the technical department of the United States Golf Association (USGA) in Bernardsville, New Jersey, recently, I saw researchers using digital television cameras to record golfers' drives for analysis on a powerful Sun work station.

Sports scientists have also produced enormous quantities of new equipment over the years. Sporting goods (including clothing) is a \$45 billion industry—though it is often hard to tell whether it is competition in sports or in fashion that moves consumers to buy. The impact of all this new gear varies from sport to sport. Studies of professional performance in golf, for example, show a perceptible but very slow decline in average scores over the years. For ordinary players, however, the payoff is probably more psychological than ballistic. Frank Thomas, the USGA's technical director, believes that new equipment can keep the conscious brain from spoiling the unconscious brain's natural performance—for a while. Then golfers become self-conscious again and revert to their old problems.

Golf may be unusual for its gradual approach to technological change. New technologies have drastically altered certain sports: the fiberglass pole transformed pole vaulting during the 1960s; echolocators have given tournament bass fishing the quality of a video game. But again the overriding fact is that the same technology has been as readily available to amateurs as it has been to paid athletes. The professional's edge is mainly in service and customization, often provided without charge as part of an

endorsement package.

The heroic approach to athletics still has many partisans. The Yale classicist Donald Kagan rejects the idea of elite athletes as highly skilled workers. He holds up baseball during the 1950s as an idyll of power and grace: "The Yankees ruled this world as the Olympian gods ruled theirs. . . . with steadiness, serenity, and justice, and only the unworthy gnashed their teeth in envy and prayed for chaos to shatter the unwelcome order." He prizes baseball's greatest players not for their "smarts" or perseverance but for "the qualities of courage, suffering, and sacrifice." And as any admirer of aristocracy must, he exalts inborn excellence over acquired proficiency.

Kagan wrote in good-natured reaction to George F. Will's best-selling *Men at Work* (1990), which is in many ways the distillation of modern attitudes toward sport. Will begins his book with a discussion not of a great hitter or legendary pitcher but of a manager, Tony La Russa of the Oakland Athletics. And there is not much that is heroic or inspiring about him. He is an intense and supremely watchful executive, armed with copious information about each opposing player. He pursues the game methodically and presides over a corps, not of heroes, but of master artisans in various specialties: third baseman, catcher, etc. Baseball La Russa-style is not pursued on a field of chivalry but in a kind of patriarchal athletic factory.

With the rise of sports science and technology, however, the modern athletic ideal is no longer the hero of Kagan or even exactly the artisan of Will, but something else: the professional. Reviewing a book on the rise of professional society recently, social historian Jose Harris observed that "work and play, brutally estranged from each other by the early stages of industrialization, have now reconverged." Harris went on to note that play is returning to work

through the rise of business lunches and other job-related social events, but it could be said with even greater force that work is rapidly finding its way into play. The tower at Lawrenceville, for example, points to a new incarnation of Taylorism. Once imposed on a recalcitrant working class, Taylorism has become the plaything of elites who are adopting it in their leisure time, voluntarily, for the sake of winning. Middle-aged tennis players even pay stiff fees to attend grueling "vacation" tennis camps conducted by famous coaches. As technology, training, and sports science improve performance, contests in many sports depend on smaller and smaller margins of superiority. In the Tokyo World Athletic Championships of 1991, Carl Lewis sprinted 100 meters two-hundredths of a second faster than Leroy Burrell, and all of the other four runners were less than 0.2 seconds behind Burrell. Because small differences can translate into immense differentials of reward, the athlete can no longer function as an autonomous agent, as the fictional Stover did, but must depend on the contributions of more and more people. He or she needs the help of many others—not just coaches and trainers but psychologists, shoe and equipment manufacturers, trainers, financial managers—the invisible teammates.*

It isn't only the flood of money into college and Olympic sport that has undercut amateurism. As preparation becomes more arduous and intense, as standards rise, accomplishment requires a professional level of commitment. In the end, the rules and forms of amateur qualifications persist, but in many sports maintaining amateur status is a preprofessional ritual rather than a value in itself. Future contracts, signing bonuses, and endorsement income are subjects

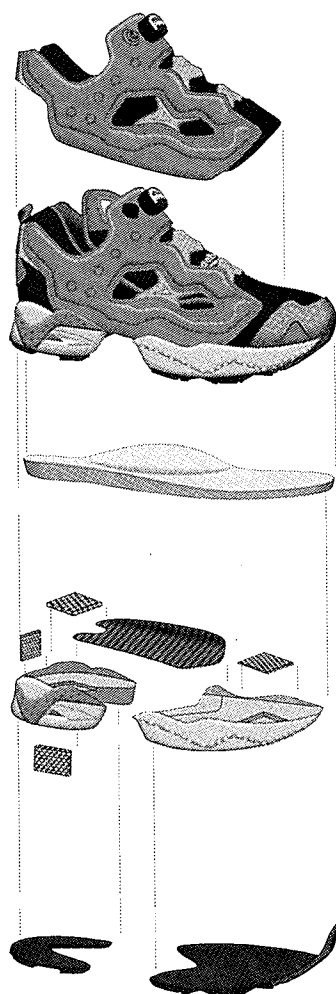
*Technology does not just introduce new materials and techniques. It develops extended networks of people. And that, paradoxically, is one reason for the absence of major new sports based on new technology. It takes a long time to build a network of athletes, manufacturers, and coaches, not to mention spectators. Better to refine existing sports. The end of this technology-rich century has no innovation to compare with the creation of basketball at the end of the last one.

of open speculation. The line between philanthropic support of sports and commercial sponsorship blurs hopelessly. Is it any wonder that amateurism has become a hollow ideal, tainted by social exclusivism, a concept that went out with Avery Brundage and tennis whites? (The 11th edition of the *Encyclopaedia Britannica*, published in 1910, reported that the Amateur Rowing Association of Great Britain disqualified anyone who had ever earned a living as a "mechanic, artisan, or labourer.")

In the postamateur world of sport, more and more participants are happy to be part of a technological system. About the same time that Lawrenceville adopted its hydraulic lift, there appeared at a local shopping center a new indoor golf practice range where players could have their swings videotaped. Some critics fear that we are "taking the play out of play"; some players seem happier than ever, though, with the latest oversized golf club or tennis racket. Will this continue, or will there be a traditionalist counterrevolution in sport as part of a more generalized reaction against professionalism in society?

In a sense, technology has restored some of the importance of the "natural," if not the hero. It has encouraged national and international talent searches that have turned up athletes whose body types are more and more precisely matched to the demands of their sports. As was noted recently on a public television show, swimmer Mark Spitz electrified the world by winning eight gold medals at the Munich Olympics of 1972, yet 20 years later none of his Olympic records would have been good enough to get him a place on the U.S. Olympic swimming team. In 1992, Spitz still had the world's most efficient technique by the standard test; his successors were just stronger and more powerful.

If a return to the cult of the natural player is unlikely, a cultural reaction against the rationalization of sport is more plau-



among the genteel. Sylvester Stallone's *Rocky IV* (1985) has Rocky Balboa confronting the Russian champion Ivan Drago, a steroid-filled colossus who trains with technicians in a futuristic wonderland of sensors and monitors. Rocky, "all heart" as his trainer puts it, prepares for the fight in the homely seclusion of an Old Russian dacha, jogging through snowdrifts with logs in tow. Ultimately Rocky wins a rousing triumph against the giant's machine-like attack.

Some modern sportswriters speculate about the coming of a new age of cyborg athletics, pitting genetically selected or manipulated superathletes against one an-

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Manufacturers now use the language of engineering to sell their wares—in this case, Reebok's new Instapump™ Fury running shoe. Americans spend more than \$6 billion annually on athletic shoes.

sible. German sport may be most famous for the Nazi spectacle of the 1936 Olympics in Berlin and for the former East German training machine, but it also has a powerful romantic tradition. German gymnasts long resisted competitive scoring, as Allen Guttman has pointed out, and refused to participate in Pierre de Coubertin's first Olympic games a century ago. Adolf Hitler, always a ruthless modernizer, had to dissolve the Deutsche Turnerschaft (German Gymnasts' Society) for its opposition to—in one writer's scornful list—"concrete stadium, cinder track, tape-measure, stopwatch, manicured lawn, and track shoes." In our own time, the romantic tradition in sport remains powerful—and not only

other. Their predictions may turn out to be correct. But no technological change is inevitable. Change is shaped by the law, by politics, by public opinion, and by many other diffuse influences. Decades of fantasies about synthetic food, clothing, and shelter were shattered by the growth of the popular taste for all things "natural" since the 1960s. In sports, spectators and athletes want to win as badly as ever, but the desire for a more humane style of sport and for the old sporting virtues remains strong. On the golf course, amateur players are perfectly free to agree among themselves to allow the use of asymmetrically dimpled balls banned by the USGA from tournament play, but they rarely do. They likewise spurn the me-

ticulously engineered putters that swamp the Patent Office. And professional baseball years ago rejected the aluminum bat. The renaissance of minor league baseball in the 1990s suggests that many people will forego world-class play for a friendlier setting. As a rule, the biggest sports stars are still those who, like Michael Jordan, are capable of breathtaking feats that are prized precisely because they would be impossible without some great gift of nature. And a few new sports, such as ultimate frisbee, rollerblading, and wind surfing seem to have benefited by purposely keeping their distance from big-time college athletics.

What is important about amateurism is not its fastidiousness about money. If writers and artists can accept corporate commissions without losing their souls, why can't athletes? It is the focus on the whole person, the refusal to let sport or work or anything else take over one's existence, that is most important. Technological intensification does not rule out this amateur spirit, but it does set traps, just as computer power does. The steroid-pumped colossus and the caffeine-and-sugar-braced computer hacker are stereotypes with bases in fact. The burden cannot rest only with individual athletes. Gov-

erning bodies in all sports must look harder than ever at new technologies and their likely effects, positive and negative, on the spirit of the game. The most sophisticated of these bodies, such as the USGA, have been able to walk the fine line between innovation that enhances the enjoyment of a game and escalation that robs it of its challenge.

Over the last 200 years, the typewriter and computer have not made writers better or even more prolific than Jane Austen or Charles Dickens. Even in major branches of science, from pure mathematics to evolutionary biology, today's best minds still revere and profit from Karl Gauss and Charles Darwin. Among the professions, only medicine and dentistry are unquestionably and consistently better than they were long ago. But thanks in large part to technology, athletes are still surpassing the accomplishments of their greatest predecessors. And many athletes at the highest levels are reaping unprecedented financial rewards from the power of television and other media to fuel the machinery of money and stardom.

But athletes have also found themselves embedded in an athletic-technological-entertainment complex that has them always in its sights. Like it or not, they have found themselves under the eye in the sky.