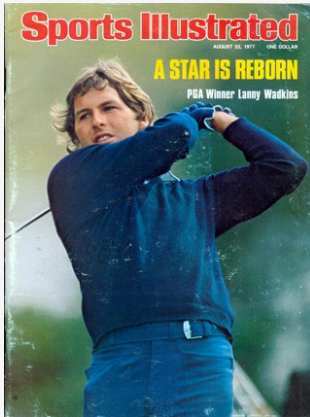




# Gideon Ariel and his Magic Machine

If you want to run faster, throw farther or jump higher



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## Sports Illustrated

In this Sports Illustrated article, the work of Gideon Ariel, a pioneer in the field of sports biomechanics, is explored. Ariel has spent over 10,000 hours programming his computer to analyze an athlete's motions, challenging the traditional belief that trained observers can discern the crucial elements of athletic performance. Ariel argues that the human eye cannot quantify human movement and that the timing, relative speeds of limb and body segments, and changes in centers of gravity must be measured, weighed, and compared to be of any use.

Ariel's work has revolutionized sports, allowing for the first time a detailed analysis of the line and meter of human motion. His computer programs have been used to analyze and improve the performance of athletes in a range of sports, from discus throwers to long jumpers. Ariel's work has also debunked some common misconceptions in sports, such as the belief that strengthening the forearm muscles can improve a pitcher's throw.

The article also discusses Ariel's future plans, which include using his technology for injury prevention and treatment, and the potential for individualized training programs based on an athlete's unique biomechanics.

In this article, the author discusses the work of Gideon Ariel, the founder of Computerized Biomechanical Analysis (C.B.A.). Ariel's work involves using computers to analyze and improve the performance of athletes. Despite facing legal battles and resistance from traditional coaches and corporate sporting-goods executives, Ariel remains dedicated to his work. He believes that his methods can revolutionize sports by providing more accurate and objective measurements of performance. Ariel's work has potential applications in product development and could change the way sports like diving or gymnastics are judged. Despite the challenges, Ariel remains optimistic about the future of his work and is even planning to use his methods to help former Olympic discus champion Al Oerter improve his performance.

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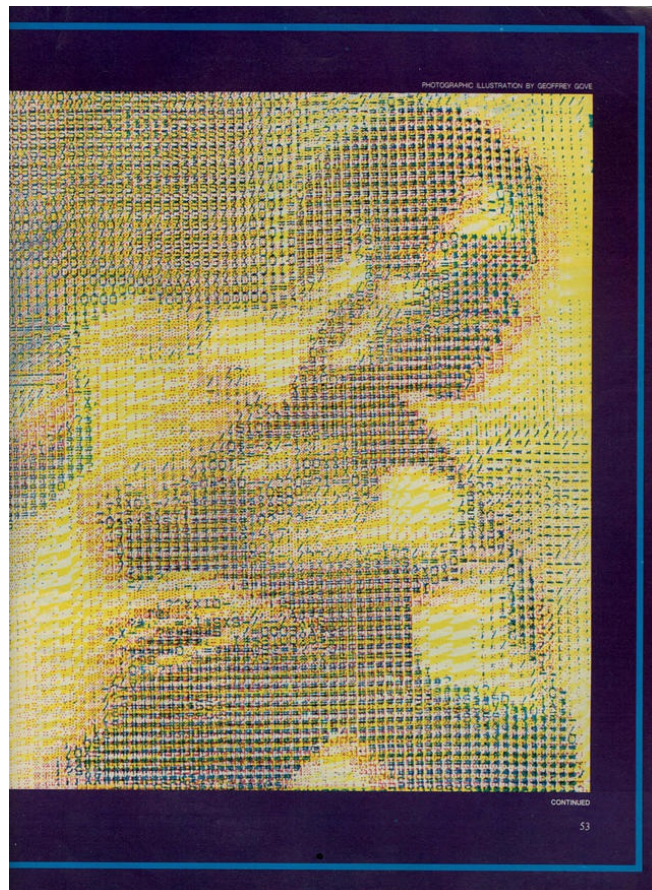
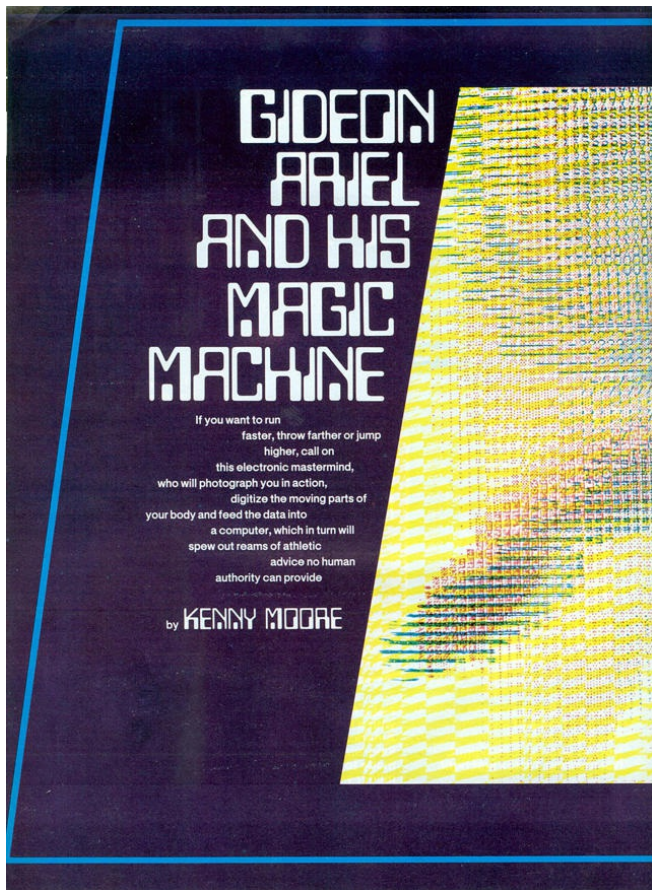
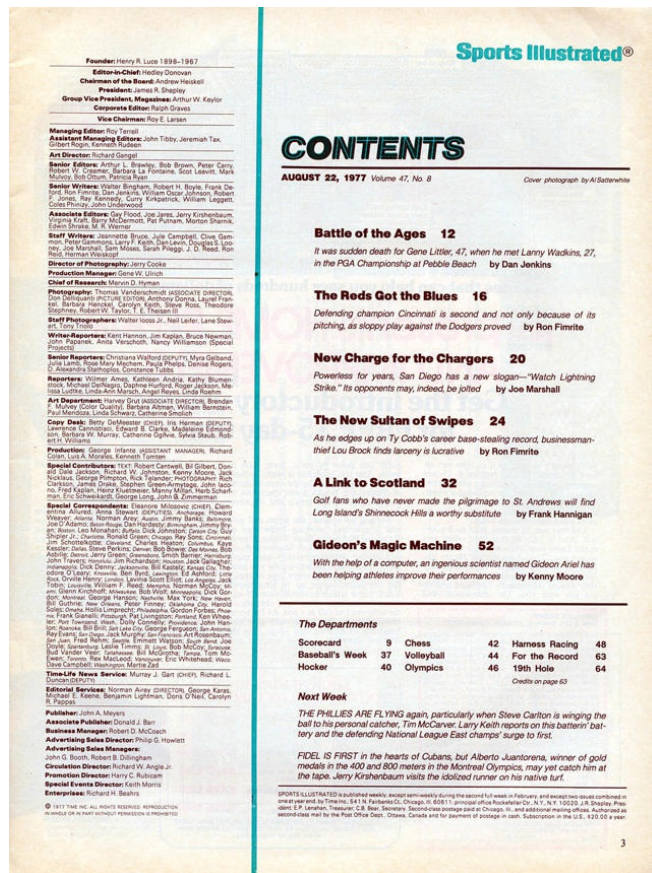
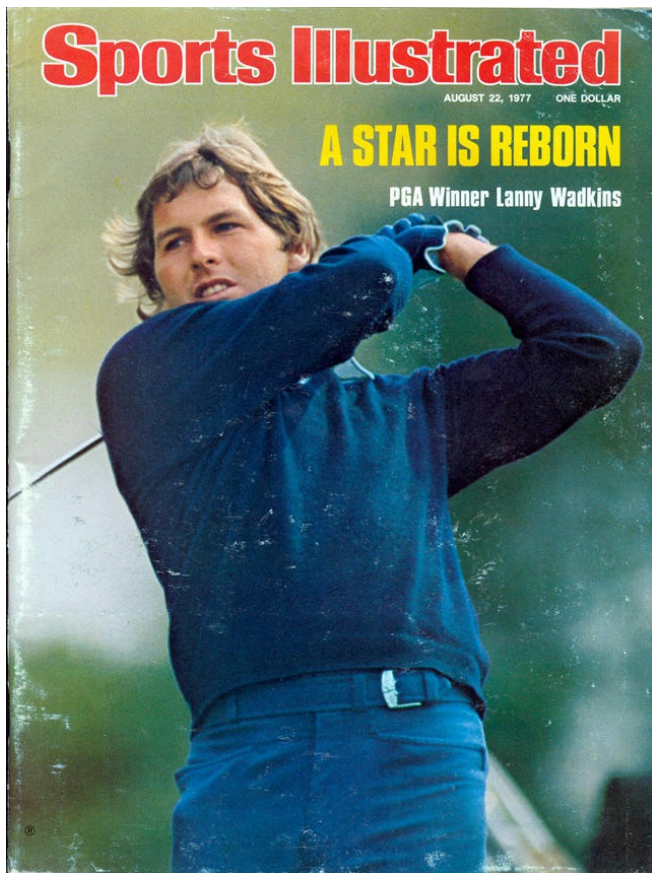
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Below find a reprint of the 11 relevant pages of the article "Gideon Ariel and his Magic Machine" in "Sports Illustrated":





## COMPUTER

"Faith" is a fine invention  
When Gentlemen can see—  
But Microscopes are prudent  
In an Emergency.

—EMILY DICKINSON

Around Amherst, Mass., colleges run into colleges—the University of Massachusetts, Hampshire, Amherst, Mount Holyoke, Smith—leaving little room for a real town. The population is incessantly changing, fresh ideas flowing through a setting that has a history of assisting clear thought, elegant patterns. Emily Dickinson wrote and is buried here, and Robert Frost's birches are still bending.

Working today in Amherst is a man who would hardly consider himself poetic, but Gideon Ariel has been a leading figure in taking the great raw minds of computers and bringing them to bear on movement. In so doing, he has for the first time let us see the line and meter



It took Ariel more than 10,000 hours to program his computer to analyze an athlete's motions.

of human motion. Sport can never be the same.

In the first place, it seems that we have been proceeding on a false assumption. We have believed that trained observers can discern the crucial elements of athletic performance, that coaches can see what their athletes are doing wrong. "The human eye cannot quantify human movement," says Gideon Ariel, ponderously, because he is a big man who threw the discus and shot for Israel in two Olympics, because he still struggles with his Hebrew accent after 14 years in this country, and because that sentence is the foundation of his revolutionary advance. "The important things in performance,

the timing, the relative speeds of dozens of limb and body segments, the changes in centers of gravity—these all must be measured, weighed, compared to be of any use."

Ariel is a natural teacher, reaching always for images so vivid the dumbfounded or skeptical will be forced to see. "Compare coaches with bridge engineers," he says. "Suppose an engineer finishes the bridge and says, 'Wait, remove the discus and why, and he says, 'I took a survey of 100 drivers, and 75 said it looks better without the beam.' That is how coaches coach. What looks best. But if an engineer did that there would be a lot of cars in the river. And he would

find himself in the nuthouse, because he is required to measure the strength of his materials and design against the weight of his load."

People are subject to the same physical laws as bridges. Indeed, Leonardo da Vinci believed mechanical science the noblest, "seeing that by means of it, all animated bodies that have movement perform all their actions." Isaac Newton described the laws of motion in 1700, but not as vibrantly as does Gideon Ariel. "It doesn't matter if you lift a cow, or throw a chair, or punch your girl friend. Everything is according to Newtonian physics."

The problem, until now, has not been that we haven't believed this, it has been that too many things happen too fast for us. The sheer complexity and velocity of a javelin thrower's movement in the final quarter second before release, for example, preclude comprehension of what is going on.

Technology helps. One of the earliest uses of photography was to settle the turn-of-the-century question of whether all four hooves of a galloping horse ever were off the ground at once (they are). In the 1930s, high-speed cameras provided slow-motion photography to offer a clearer view of the action. Dozens of limb and body parts accelerating and decelerating could be seen and measured and charted against one another. Patterns of successful athletes began to appear.

"The better the athlete, the more sophisticated his timing," says Ariel. "The one basic principle of all sports—hitting or kicking balls, punching, throwing, jumping, breaking karate bricks—is a coordinated summation of forces."

But so delicate are the relationships between an athlete's many moving parts that they cannot be assessed simply by looking at the slowest of motion pictures. A process of frame-by-frame, body segment-by-body segment analysis is necessary to make optimum use of cinematography, work that is painstaking, dreary and absurdly time-consuming. Gideon Ariel gave that work to the computer and suddenly the maddening complexity of

human motion could be matched by the awesome memory and speed of the machine. Well, not quite suddenly. It took Ariel some 10,000 hours over seven years to create the programs that instruct his computers. Now he offers the sporting

world a chance to lift itself from, as he puts it, "the dark ages, a witchcraft business where everything is made of thin air." Over those years, Ariel transformed himself as well, from a carefree discus thrower to a compelling, capricious figure.



Digitizing, Ariel uses his sonar pen to determine the coordinates of javelin thrower Bill Schmidt.

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## COMPUTER

ure, half academy lecturer, half medicine-show barker, a character entirely appropriate to spark the gap, to complete the circuit between science and sport.

Gideon Ariel is a fleshy man, with direct, hazel eyes and a shock of black curls graying at the temples as he enters his 39th year. His accent bears a resemblance to that of Alan Arkin playing Freud in *The Seven-Per-Cent Solution*, but he shouts more. Occasionally brilliant explications to visitors or students

numbers meant little to him, but not Ariel's interpretation. "He pointed out that my front leg was absorbing energy that could go into the throw," says Wilkins. "I had to begin to change my whole conception of throwing. I used to think I had to put as much of my speed as I could in the direction of the throw."

Ariel, citing Newton's law about every action requiring an equal and opposite reaction, said no. "It's vital to have everything stopping in the discus. In the

record, eventually reaching 232' 6" and winning the Olympic gold medal at Montreal. He continues to throw, calmly maintaining he has not lived up to its potential, and for once that is a judgment supported with clear evidence. Shotputter Terry Albritton's mistake was similar to Wilkins'. "That front leg has to be the solid block you throw from," says Ariel. "What Terry was doing, bending that knee, was like trying to throw from a trampoline or shoot a cannon from a canoe." A year ago Ariel told Albritton he could be the next world-record holder if he'd stop doing that. A month later Albritton was the next world-record holder, with a put of 71' 8 1/2".

Sometimes the camera and computer happen upon events that bluntly refute accepted theory. Long jumpers have all trained by rising to their toes under heavy weights, strengthening their calves for the last push from the board. Ariel's analysis showed, however, that the best jumpers don't point their toes until the pushing foot is already two feet off the ground. "Far more important than the jumping leg is the free leg," says Ariel. "It and the torso accelerate as the planted leg decelerates. Then the jumping leg is yanked off the ground. That leg isn't pushing. It's trying to catch up."

In a study of Kansas City Royals pitchers, another commonsense belief fell to clear measurement. "You'd think if the forearm muscles that flick the wrist were stronger, you'd move the wrist faster and throw harder," says Ariel, illustrating by flapping a limb in the manner of a rather aggressive princess thrusting her hand out to be kissed. "But no. Because of the whip action, the concentration of force from the legs and back and shoulder, the forearm is like the end of that snapping towel, the wrist snaps far faster than any muscle can contract. It just goes along for the ride, so it is absolutely useless to train the wrist."

No sport is immune to Ariel's iconoclastic examination. Not long ago, he and his staff spent 4,000 hours analyzing the behavior of tennis balls, filming them at 10,000 frames per second as they struck rackets and assorted surfaces.

"Tennis people think they can feel the ball on the racket. They talk as if they can do things to control it then," says Ariel, waving an imaginary racket. "We

discovered that a tennis ball is on the racket approximately four milliseconds. Four one-thousandths of a second. Human reaction time is 120 milliseconds or more, so that ball is long gone before anybody feels it. It is off the racket even before the racket feels it." Such a sharp jolt obviously packs a great deal of energy into the briefest of moments. "The muscles can't react to it, so the elbow, which is a single place joint and can't pass any of the shock along, can briefly receive a hundred times the force it does when you throw something. No wonder people get tennis elbow."

The tennis ball study was commissioned by a manufacturer who will use the results to design balls that remain on the racket longer. But Ariel was most fascinated by having to devise a new equation to describe the behavior of elastic objects colliding at oblique angles, because these didn't seem to follow textbook physics. "The point of maximum compression is not the point of maximum force," he says excitedly. The commercial overtones of the research did not hold his interest. "They talk about light balls, heavy balls. Such craziness. All the brands were so much the same it was like they were made by the same machine."

Because so many of the body's reverberations end up in the feet, Ariel has long been interested in athletic shoes. "That is the witchcraft business, for sure," he says. "Shock absorption is the key to better distance running, no question, but look?" He flips through a book of data. "Some brands absorb 2,300 newtons, some only 1,000. That range! And the manufacturers don't even know what their own shoes do."

Ariel, using an exquisitely sensitive \$25,000 force plate, which transmits readings of four kinds of pressure—vertical, forward, sideways and twisting—to an oscilloscope, charted the forces of footstrike in different shoes at every point of foot placement. "You see pictures of runners, it looks like they're landing on their heels, but they're not. The good ones don't. They flick the foot down flat at the last instant. All these companies are making wonderful heels and the best runners are never coming down on them." One company, Pony, bowed to Ariel's advice and has brought out a shoe tested in his lab.

Visiting Ariel's office and laboratory, tucked away in a storefront between Erik's Giant Subs and Radio Shack, one sees wonders everywhere, like the electronic display on which he can call up the style of a shotputter or quarterback in the form of a sequence of glowing green stick figures. "You have to be very responsible to change the form of any good athlete," he says. "The better the athlete, the more it seems wrong to fool with him." So Ariel has programmed

cleared 7' 11". So we will one day see an eight-foot high jump." Bud Greenspan, who produced *The Olympian* series on PBS television, provided Ariel with slow-motion film from 1936. He wanted to know who was the better sprinter, Jesse Owens or Eddie Hart, the present colholder of the world record for 100 meters at 9.9 seconds. Owens had run 10.2 on cinders, without starting blocks. Hart on polyurethane, with blocks, but Ariel saw no



When Mac Wilkins heeded the advice of Ariel's computer, he set a world record in the discus.



After Terry Albritton quit bending his left knee on Ariel's advice, he set a world record in the shot.

are followed by awkward silences because his Hebraic rhythms have made "quats" and "kets" of quartz and cats. Because photography is crucial to biomechanical analysis, Ariel speaks often of "illusions." But it is Ariel's work, not his speech, that has made him a hero to hundreds of athletes.

In November 1975 the U.S. Olympic Committee assembled the 12 best American discus throwers in Los Angeles where high-speed cameras photographed them in action. The film was flown to Ariel's lab in Amherst, where he calculated the forces and accelerations of the athletes' body segments. Ariel himself flew back to California with the results, plotting 50-to-80-page computer print-outs into the bemused throwers' laps. One recipient was Mac Wilkins. The sheets of

best throws, we found a pattern. It is like using a fly rod, or snapping a towel. You have to decelerate the heavy parts, the legs and the trunk, so you can accelerate the light parts, the arm and the discus." Ariel spoke to Wilkins with special care, because the analysis had shown him generating incredible speed in one section of his spin. "He was like 30% faster than the rest, even though he was dissipating it at the end. But if you see that, you know the potential is there." The computer found that with a perfectly timed summation of his forces, Wilkins could throw the discus 250 feet.

"It seemed a little far at the time," says Wilkins, whose best was 219' 1". Indeed, the world record was 226' 8". But the second and third times Wilkins put Ariel's advice into practice, he broke the world

problem. "We knew the angular displacements, so we knew how many degrees per second their ankle, hip and knee joints displaced. We knew the length of the bones and the speed of the film frames, so we knew how much distance was covered per second. We let each man cover 100 meters and computed the time it took him." The winner? Jesse Owens.

The precision with which Ariel's machines can trace movement patterns has widespread application in injury prevention and treatment. "Any little pain will change the pattern of locomotion," he says. Just now, Ariel has finished an analysis of film sent by the Dallas Cowboys, who wanted to find out if injured players were returning to normal patterns. The possibilities for rehabilitation, or

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## COMPUTER

continued

the teaching of any sort of muscular coordination, are enormous, especially now that Ariel has a little computer that can take instructions from a stick. Unlike the \$8 million University of Massachusetts computer that Ariel dealt with through telephone connections and a Telex keyboard, his new one, the size of an electronic stove and costing only \$60,000, displays a set of functions on a screen and the operator selects the one he wants performed by directing a floating indicator light with a lever Ariel calls a joy stick. The joy stick goes a black, magnetic insert that can hold nearly a million bits of information. The term for these is flexible diskettes—"floppy disks," in Ariel's argot. "In scientific training, a man will have his own floppy, containing his whole athletic history and an individual program computed for his needs. As he works in the gym or on the field, the computer will monitor him, giving him instant feedback directions . . . congratulations." Dr. Gerry Purdy, author of *Computerized Running Training Programs* and one of the few men in the field who share Ariel's dual expertise in computers and exercise science, says of this, "My first reaction is that he's bordering on artificial intelligence. Academically, it's not unreasonable, but from a practical standpoint, it's like *Star Wars*."

Yet clearly the last obstacle to such an instant system is the fact that film takes time to be developed, and video tape is not yet a suitable replacement because of insufficient clarity and speed. But we are at a stage now where a computer can divine an athlete's optimum technique in an event and coach him toward it. "Of course, if a high jumper doesn't want to land on his back, that's another problem," says Ariel. "That's psychology. We can't do anything about that."

Gideon Ariel's own psychology is nearly as fascinating as his science. A clumsy, shy boy, he grew up in a boarding school near Natick, about 20 miles north of Tel Aviv. Poor in sports, he nonetheless longed to be an athlete, and in 1956, when he was 17, he found that the best Israeli discus man had thrown less than 160 feet. Something clicked. "I can do better than that," he said and embarked upon four years of training, almost demented in his intensity. Speaking to a class at Amherst, he said, "If

you want to be a discus thrower, you have to live with the discus. Carry it with you. Sleep with it."

That is what he did, with both shot and discus, throwing them as much as eight hours a day. "I threw from pictures. Coaches meant well, but one would say one thing, another would contradict him. It was all opinion. How did they know?"

One who knew a lot more than the rest was Dr. LeRoy Walker of North Carolina Central, who later became head coach of the 1976 U.S. Olympic men's track and field team. In the late '50s, Walker coached Ariel and Ariel. "He told us to do things we never did, like sprints and weight lifting, and we were all so sore after the first day we said, 'This guy is crazy.' But he had a method. He said, 'Go throw 500 times and we will talk. I can't tell you anything now because your variability is so great.' It worked. I got a pattern down and we could go from there. We talked about forces and angles. It was the beginning of a scientific approach."

They also talked about college scholarships, and after Ariel had taken part in the Rome Olympics and spent three years in the Army, he came to the University of Wyoming. "My life was just to throw the discus," he says.

When he graduated in 1966, it was found that Ariel had spent three years at Israel's Wingate Institute, earning a Diploma of Physical Education degree in 1960. He had never thought to tell anyone about it and had thus completed three years of U.S. college athletic competition without being eligible for it. "Wyoming was fun," he says now, "but the coach wasn't like Dr. Walker. It was back to opinion."

Ariel applied to the newly created School of Exercise Science at the University of Massachusetts, got his master's degree in nine months, became an assistant track coach and then plunged into an eclectic set of studies with all the fervor of his early years with the discus. "There had to be 20-hour days for him then," recalls University of Massachusetts Track Coach Ken O'Brien. "I'd find him sleeping at his desk in the mornings. A professor in one of his classes would mention some advance in an allied field, like calculus or cybernetics, and Gideon would go over and take the course."

One such suggestion came from the head of the computer science department. "He said, 'Why don't you apply computers to your mechanics?'" recalls Ariel, who was sick of laboriously tracing every joint on paper, limb by limb, frame by frame. But how? How to find a way of getting all this raw information into the computer? The answer was a device called a digitizer, a screen lined on two sides by 20,000 tiny directional microphones. The coordinates of any point on the screen touched with a sonic pen are automatically registered and fed into the computer. While visiting the Dartmouth Medical School, Ariel happened across one of these instruments, which all looks not unlike a movie screen mounted in a console. "Then in 1968 Dartmouth started the computer time-sharing concept. The potential was unbelievable. All I needed was a \$50-a-month rental to put a terminal in my house and I could do anything."

With his keyboard terminal installed, Ariel plunged into writing computer programs. "The whole idea is simple," he says. "Human beings are creative, but we have terrible memories. Computers are dumb, but their memories are perfect. You have to guide them, lead them step by step, channel your creativity through the software, the programs, till you have created a monster. It grows and you have to write more and more programs so it can do more and more things." What sustained those thousands of hours of labor?

"That was hard to figure out, how to get them working together without burning everything up. The exciting part is the conceiving, the finding out what you think you can do. Then it takes a long time to get the computers to actually do it." In other words, this is exactly like any other worthy craft. In 1971 Ariel founded Computerized Biomechanical Analysis, or C.B.A., and landed a few contracts testing basketballs for Spalding and shoes for Uniroyal. This allowed him to purchase more advanced equipment. Purdy predicts that Ariel is now about to reap rewards far above professional satisfaction. "If he's solved those problems of practical application, he'll find a ton of marketable uses."

Look what digitizing analysis could do for the sports that are now judged subjectively, like diving or gymnastics. For the first time we could really measure how close a performer comes to perfection. Think of that, we wouldn't have those prejudiced Russian judges in there messing up results."

And there is always the lucrative world of product development. The key to opening it is the software, those valuable programs that are generally not copyrighted (one tiny change in a lengthy series of instructions to a computer obviously can cause drastically changed results). Add the fact that few scientists in the field are business oriented, least of all Ariel, and the situation seems ripe for corporate wrangling. Since receiving his Ph.D. in exercise science in 1972, Ariel has been involved in a train of legal skirmishes with an exercise-equipment company that couldn't stomach his analysis of its product (settled out of court with a public apology to Ariel), and with a colleague and one-time professor over some rights to C.B.A. Possessed of an unshakable faith in his own rectitude, Ariel will surely live out his life as one of those litigation-prone scientists—*à la* Vinci—one who feel somehow unclothed unless they have six lawsuits pending.

Gideon Ariel does not claim to be a true pioneer in biomechanical analysis. Sweden's Ingvar Fredricson has been studying the motion patterns of standard-bred horses with a computer for 10 years, predicting lamenesses from minute stride irregularities, and discovering that most trotting tracks are banked too much on the straightaways and too little on the turns, placing dangerous stress on delicate forelegs. At Penn State, Peter Cavannah is well along in a study of human stride patterns. But as Ed Burke, the U.S. record holder in the hammer throw and a close friend of Ariel's, says, "A lot of biomechanical people are contributing in their own quiet way. Gideon is contributing in his own, uh, inimitable way."

Ariel has had occasion to see what he might have ended up doing had he not harnessed the computer. "In 1972 I was in Spain and met with some East German coaches. I looked at the East German shotputters and saw that they all threw with exactly the same form, as if they had been molded that way. They all lifted their back legs before they re-



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## COMPUTER

continued

leased the shot. I mentioned this and a coach said, 'Oh really? We'll have to correct that.' I said, 'Don't give me that. It's good.' I knew we had something in common, a shared knowledge. Equations of motion are equations of motion. I saw notes from years before. Those men began long before I did. But they'd been doing it by hand. Imagine 15 engineers working a month to chart one shotput!"

There are times when Ariel becomes unabashedly sentimental about his U.S. experience, and this memory triggers a paeon to the American system. "There was a time when we needed to know relative weights of body segments. We wrote to NASA research and they sent back books of data. No charge. That was a tremendous help. We couldn't have gone on without it. But in East Germany they would say, 'Confidential, classified.' Here, people are open-minded."

As if in recompense, Ariel has offered his services at cost to the U.S. Olympic Committee as it readies for the Moscow Olympics. "Until 1964," he says, "talent alone still worked. Since then sport has been a science, not an art. There is no way anyone is going to beat the talent in this country if it is properly prepared." Since May, Ariel has been spending half his time at the newly opened Olympic Training Camp at Squaw Valley, Calif. (page 46), working with field hockey players, soccer players, women's basketball players, kayakers and swimmers. As usual, he has doled out hours of fascinating advice. What is the optimum free throw? "The more limb segments you use, the more chance for error in coordination," he says. "The best players just use the knees for lift, and flip with the forearm. Simplest is best." In a skill as basic as jumping, Ariel brought about a two-inch improvement in one female basketball player whose coach had had her bending her knees too deeply before ascent.

The ice hockey coaches were reluctant to use Ariel's services until he explained to them, for the first time, just how it is that a slap shot by a small player can attain much greater velocity than a sweep shot by a monster. "The better shooters hit down on the ice behind the puck and bend the stick so it becomes loaded with energy. Then they flick the puck, like this," he said, flipping paper balls at the astonished and somewhat embarrassed coaches.

Indeed, Ariel's findings and progress in biomechanical research present a challenge to all coaches. After he stops calling them witches and predicting that a computer-monitored individual training system will do away with them, he backs down a bit, saying, "I can't coach the Dallas Cowboys, but I can give them more information. I can tell them where and how to hit the other players, how to create the greatest force in blocking, how to brace knees, improve helmets. People cry about removing the art from sport. But they started it. Why do you time a runner, or measure a jumper, or count goals? Maybe we shouldn't. But once you decide to use all those numbers, O.K., he's really using them." This has some added force, said as it is while Ariel dramatically unfolds a printout of thousands of multidigit measures of Offensive Tackle Rayfield Wright's center-of-gravity fluctuations, the paper spilling across his desk and onto the floor.

Ariel's old boss, Track Coach O'Brien, has thought about the threat he poses to old-school coaches. "Gideon assumes, rightly, that most coaches don't know biomechanics, physics or biology, and haven't got a burning desire to learn. Coaches just use what has seemed to work in the past. It's true that you can't see enough. We see positions, we see lines, but we don't see magnitude, how hard that foot is pushing. If we are willing to admit we're inadequate in those areas, we will use the techniques he has developed."

O'Brien sees a possible source of resentment in the necessity of coaches relinquishing athletes to outside analysts like Ariel. "Nobody likes to share the credit." O'Brien has observed Ariel's presentations to several coaching clinics. "He's a good entertainer. You pretty much have to respond to the force of his personality, so it is illuminating to watch the people when he's done. Some rush him for more and more. They're all saying the same thing. 'Where can I use it? How the heck can we make it available?'" The servers are turned off. They drift out shaking their heads, sullen.

One sees the same dark clouds on the brows of corporate sporting-goods executives that fogged the brains of Gallileo's judges. Science is no respecter of tradition, and Gideon Ariel is a man of pure, almost innocent, science. In his lab is a

scientifically designed shotput shoe. It has laces inside its laces and is twisted, as if a truck had run over it. "Did you ever see anyone put the shot while standing up straight?" No. This shoe cocks the foot into position and the double laces save energy. It works. "No manufacturer will touch it. 'It wouldn't look so good the next day,'" Ariel says. "And how many shotputters are there in this country?"

A maker of golf shoes wanted C.B.A. to prove its shoes were the most comfortable, comfort being the basis of its advertising. Science had other ideas. "What is 'comfortable?'" Ariel demanded. "Does that mean a man can swing better? What if the best shoes for golf shoes make a man limp down the fairway? You cannot high-jump in comfortable shoes. You cannot shoot a cannon from a canoe because the canoe is going under the water. . . . The golf-shoe people departed with pinched expressions. Later they retained Ariel's services, warily."

A ski-boot company once got Ariel up to Vermont to analyze the forces on the ankle joints of a downhill skier. He proposed, for safety, the use of electric strain gauges on the bindings. "It was as if someone said to General Motors, 'Make an electric car.' It was too revolutionary. There is one word that seems to paralyze these people—that is 'retol'."

Yet Ariel does not brood over temporary setbacks. His company owns outright all of his equipment, so if contracts or grants should dry up, he could press on with research. And his own competitive juices still surge. Recently, he got a call from an old hero of his, Al Oerter, the 40-year-old, four-time Olympic discus champion. "We, he and I, are going to reenter the ring," Ariel says, his eyes gleaming. "We will put him in a more efficient position. We will cut down on shoe friction. We will overcome physiological deterioration with scientific advance." Ariel listens to his own echoes in the lab. "He was so nice on the phone, I had to say yes. He told me, 'We competed in the same Games.' But I didn't ever make the final."

Ariel—the scientist who is revolutionizing sport with hisonic pens and slow-motion cameras and computer printouts—smiles, seeing, perhaps, a pattern. "I was always too emotional in the big meets."