

— THE ONE AND ONLY —

rules. Where prints are involved, anything is possible. Nothing should be overlooked. For example, when labor leader Joseph Yablonski challenged the powerful leadership of the United Mine Workers union, he and his entire family were murdered. Pittsburgh police searching the area around his house found several discarded beverage cans. They had been lying in the rain and snow for at least a day, perhaps longer, and the freezing cold and wet weather certainly should have destroyed any latent prints. But this was a major case, so the cans were processed anyway—and to everyone's surprise several good prints were developed. It was later learned that the killers had waited patiently outside the Yablonski home, eating and drinking, until the family had gone to bed. Presumably grease or oil from the food had gotten on their hands and been transferred to the cans—substances that are particularly resistant to moisture. The prints enabled police to place the suspects at the Yablonski home at the time of the killings and contributed significantly to their conviction.

Making latent prints visible is really where fingerprinting becomes a science. Developing latent prints was once pretty simple. There were only four methods that worked. Dusting powder was used on nonporous surfaces, such as glass, plastic, or metal, while the chemicals iodine, ninhydrin, and silver nitrate were used on porous surfaces like paper, cardboard, and unfinished wood.

It was discovered almost a century ago that iodine fumes react with body fats and oils to make prints composed of those substances temporarily visible. In the 1950s scientists found that ninhydrin, the chemical most commonly used in fingerprint developing, reacts with amino acids or protein matter usually found in perspiration to make them visible. And silver nitrate combines with invisible body salts to form the very visible sodium chloride. These chemicals must be used in this order, or whatever latent prints might exist will be destroyed. And if these methods failed to produce prints on porous surfaces, it was generally accepted that they just weren't there.

That wasn't entirely true. The most historically significant exception took place on November 22, 1963, in Dallas, Texas, when President John F. Kennedy was assassinated by Lee Harvey Oswald. Less than two hours after Kennedy had been shot, Dallas police found a rifle lying next to a window in the Texas School Book Depository. A barricade of cardboard book cartons had been built around the window. Although Oswald's right palmprint was found on the rifle's stock, someone could have left the rifle there to im-

plicate him. Following standard crime-scene procedure, detectives searched the area for latent prints. Oswald's fingerprints and palmprints were developed on three of the cardboard boxes and on a paper bag.

That proved nothing. If prints are to be connected to a crime, they have to be found in places they shouldn't be found. Oswald worked in the building, so it was not at all unusual that his prints would be found there. What the police had to prove was that these were fresh prints, that Oswald had been at that window within the last few hours. Since prints can't be dated, that was an almost impossible job. But not in this case, in which Dallas detectives had made one of the luckiest mistakes in sci-crime history.

Cardboard is a porous, or absorbent, surface. Detectives should have sprayed chemicals on the boxes, but they mistakenly used dusting powder—and they had developed several prints. The question was, why? The boxes were sent to the lab in Washington for a more complete examination. By experimenting with dusting powder on similar boxes, specialists discovered it would develop prints for up to three hours after they had been made, but then the body fluids would be absorbed into the cardboard, keeping prints from being developed. The fact that Oswald's prints had been developed with dusting powder proved he had been at that window within the time frame of the assassination.

The once-prosaic world of dusting powder and three chemicals began changing drastically in the 1970s as new chemicals and new techniques were discovered to make visible prints that once would have remained undetected. More than forty new methods of developing latent prints have been found, ranging from lasers to fumes from superglue—the same stuff you buy in the store and can't get off your fingers.

With so many different techniques available, the challenge in each case becomes picking the right process. Tim Trozzi, who joined the Bureau in 1979, said, "It's a combination of skill, experience, and intuition, and quite frankly, sometimes it's a bit of luck. You have to start by considering the nature of the object you're examining, how long the print might have been there, what type of atmospheric conditions it's been subjected to, and what else might have happened to it. If it's a car, for example, we'd want to know if it had been washed.

"Then we have to consider the properties of the different methods. I know, for example, that if I use iodine fumes first and that doesn't work, I can still go back and try superglue and fluorescent dyes. But if I use superglue first, I'll ruin it for iodine, and it might even inhibit me from using

THAD EVIDENCE
BY DAVID FISHER

CHAPTER

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Number One with a Bullet: The Firearms and Toolmarks Unit

Do you know, Watson, I believe your revolver is going to have a very intimate connection with the mystery which we are investigating.

SHERLOCK HOLMES,
in Sir Arthur Conan Doyle's "The Problem of Thor Bridge"

"The President's limousine arrived back in Washington about six o'clock. Around one o'clock the next morning Cort [Cortlandt Cunningham] and I started sifting through the blood looking for lead fragments. It was tough; it was very tough." Bob Frazier, believed by many experts to be the finest firearms examiner who has ever lived, was speaking for the first time outside a courtroom about the assassination of President John Kennedy. "The yellow roses that Mrs. Kennedy had been holding were scattered all over the back of the car along with Mrs. Connally's bouquet of red roses, and we had to move them, we had to get them out of the way. We'd just reach down into the clots of blood and scoop it up in our hands and let it dribble through. Whenever we felt something gritty, we'd clean it up and if it was lead, we'd save it in a pillbox. We didn't really recover a lot of the lead."

"Guns don't kill people," proclaims the slogan of the National Rifle Association. "People kill people." Actually, bullets kill people: bullets shot from guns, fired by people. This is an unbreakable chain, a chain that can be traced from either end. From a bullet found in a victim, it's possible to determine precisely which gun fired it, and from that gun, the person who pulled the trigger can be identified. In perhaps the classic example, when

Even in what is certainly the most carefully investigated shooting of all time, the assassination of President Kennedy, the first bullet fired was never found. "From the Zapruder film we knew when the first shot was fired," Bob Frazier, who headed the firearms investigation, remembered. "It obviously missed, and hit the limb of a tree or something. There was a man standing a couple of hundred yards away who said he got hit with a piece of cement and there was blood running down his cheek. Nobody could account for it except that the bullet might have hit the curb and knocked a piece of cement out of it which cut him in the cheek. Nobody ever found that bullet. It could have gone to pieces. But it just disappeared."

Detectives use metal detectors, underwater metal detectors, crime-scene vacuums, even X-ray machines to find spent bullets. They are found embedded everywhere imaginable: in the ground, inside utility poles, inside flattened automobile tires. They are found smashed into fragments next to a brick wall. One examiner received a tree trunk; still embedded in it was a bullet from a murder committed thirty years earlier. In those cases in which bullets cannot be found, the spent cartridges become the best evidence.

One of history's most controlled crime-scene searches took place not far from the lab when John Hinckley attempted to assassinate President Reagan. Gerald Wilkes and Rick Crum were two of the first agents on the scene. "The first thing we had to do was account for all the shots," Wilkes explained. "We wanted to know where each bullet was, which would eliminate the possibility that there was a second shooter. We knew six shots had been fired because there were six fired cartridge cases in the cylinder of Hinckley's gun, and the sound of six shots being fired had been recorded on videotape. We knew that four people had been hit, so that's four bullets. Another bullet had hit the right rear window of the limousine, the fifth bullet. But we couldn't find the sixth bullet anywhere.

"We walked through the crime scene, then we crawled through it on our hands and knees, and finally we went through there with brooms and swept up everything. We collected gum wrappers, bottle caps, cigarette butts, everything. And finally we found that bullet. It had missed everything, gone across the street and hit a second-story window, and shattered. We found tiny bullet fragments on the pavement outside the window and on the floor inside the building. There was only a small hole in the glass.

"Agents at the hospital where the President was being treated gathered up all his belongings and sent them to us so we could do residue tests. Now we believed we really did have everything we needed. In fact, two nights

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are continually cutting and ripping, which destroys individual marks. Occasionally drill bits can be matched to holes if those holes do not completely penetrate a material. In the Dahmer case the holes went through the bone, and the best the lab could do was report that the holes drilled in the skulls were consistent in diameter with the recovered bits. That type of class evidence has very little value, because Dahmer's were standard-sized bits that might have been found in any tool collection.

Toolmarks examiners are also qualified to make fracture matches, to testify that at one time two pieces were part of the same object. For example, several Virginia bank robberies in which thieves used crowbars, screwdrivers, and hammers to pull out night-deposit drawers were positively connected through toolmarks found in the debris. But from the type of crime and the method they used, that was pretty obvious anyway. And it didn't help identify the gang. After one of the robberies, however, detectives found the broken tip of a screwdriver at the scene. It didn't seem like much, just a tiny piece of broken metal. But eventually several suspects were identified and a search warrant was obtained. In the suspect's possession police found several broken screwdrivers, and toolmark examiners were able to positively link the broken tip to one of the broken blades. That tip connected the thieves to that specific robbery, and other toolmark evidence connected that robbery to several others. Primarily on the basis of toolmark evidence, the entire gang was convicted of bank robbery.

Throughout history people have set out to make their marks in the world, but when weapons or tools are concerned, marks have often led to their undoing.

In the Singer-Swapp family case, Rick Crum proved there had been an unseen second shooter. But in the most controversial crime in American history, the assassination of President John Kennedy and the wounding of Texas governor John B. Connally, Jr., the conclusion reached by the lab's Firearms Unit that there was one assassin has been challenged and debated for more than three decades. This was probably the most extensive firearms investigation in history. The official determination of the commission chaired by Supreme Court chief justice Earl Warren was that a single gunman, Lee Harvey Oswald, firing a C2766 Mannlicher-Carcano rifle from a window in the Texas School Book Depository, had killed the President. Al-

most immediately, though, that conclusion was challenged. The possible existence of an unseen second shooter became the basis for countless conspiracy theories. Since that time much of the evidence has been questioned, dozens of books have been written, additional hearings have been held, and a majority of Americans continue to believe that there existed a conspiracy to assassinate the President.

Bob Frazier, then chief of the Firearms Unit, and examiners Cort Cunningham and Charles Killion conducted the original investigation. And while the crime was sensational and the result heartbreaking, the procedures the men followed were relatively routine. "We worked exactly the same way we did in every other case," Frazier remembered, "except it was decided that in this case there would be three examiners—myself, Cort Cunningham, and Charles Killion—and each of us would do his own work. All three of us came out with the same results, and those were the results that were furnished to the Warren Commission."

The actual investigation was divided into two phases: the initial firearms comparison and the crime-scene reconstruction. "We heard about it at noon," remembered Frazier, who in a career that began in 1943 has conducted more than twenty thousand firearms investigations. "That evening we got the rifle from Dallas. I think we received two cartridges at that time, and we got a third one later. We also got a loaded round that came out of Oswald's rifle. Between the time of the assassination and the time we got the rifle, we were looking for the same type of ammunition [Oswald had used]. It was Western 6.5 millimeter and we got three different lots of it. I don't know if this came out or not, but I think the CIA furnished Italy with three or four million rounds of this ammo. Italy didn't use it, so it was sold back to the U.S. on the open market. Believe me, holding that rifle was emotionally upsetting, 'cause we knew it was the rifle that had been used. I know it affected me and it still does, it still does."

Practically the first thing Frazier and Cunningham had to do was recover as much of the fired ammunition as possible from the President's limousine. "We didn't really recover a lot of the lead," Frazier said. "One bullet went through his head, caught him behind the ear. It blew out a large piece of skull that was found in the gutter. And two big pieces of that bullet came out the top of his head; one fragment hit the chrome above the front window on the windshield, and the other one hit the windshield. It definitely hit it because we found lead on the glass."

"They appeared to be two pieces of one bullet," added Cunningham,

who also did the firearms investigation of the revolver Oswald had used to kill Dallas police officer J. D. Tippit.

"What happened," Frazier continued, "I think probably in the confusion when they got to the hospital, everybody jumped out of the car and if there were lead fragments on their clothes or in their pockets or anywhere else, they fell on the ground and were just trampled on and that was the end of it. But we found core fragments that accounted for practically all of the bullet that hit the President in the head. The other bullet that was found [lying on a stretcher in Dallas] was the one that went through the President and through Connally . . . That was the one they called the pristine bullet, but it wasn't pristine at all. The commission came up with that term, 'pristine,' meaning it was undamaged. What they meant was that the nose hadn't been mutilated like the one that hit the bone and broke into pieces. But this one was flattened; if you'd taken a hammer and hit that bullet on the side, you could have flattened it just like it was flattened."

As soon as the lab received the evidence, the rifle was test-fired and the unique markings on the test-fired bullets and cartridge cases were compared to those on the bullets and cartridges recovered from the shooting. "We had a long cotton-filled box that we fired into at that time," Frazier said. "One very interesting thing about the microscopic marks is that in one of the groove impressions there was a defect to the extent that it produced a little deeper groove in the bullet. The muzzle might've had a little tick in it or something. That particular groove was later used by an outside examiner to say that in all probability Oswald had also shot at General Edwin Walker in April that year. A bullet recovered from that shooting had that one groove on it. He found other marks that he said probably came out of this gun. We did not. We felt there weren't enough marks on it to reach any conclusion at all in the Walker shooting. Bureau policy has always been if it's not positively identified it's no conclusion."

On the basis of microscopic rifling marks, the examiners were able to conclude that the whole bullet, the bullet fragments, and the cartridge cases had come from the rifle, found in the book depository, on which Dallas police had identified Lee Harvey Oswald's fingerprints. The firearms examination proved that this rifle and no other was the one from which the fatal shots had been fired. "And when it comes to the firearms part," Frazier pointed out, "there have never been any changes."

The investigation's conclusions, rather than being the end of the case, were the beginning. Almost every other aspect of the assassination scenario

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has been challenged. Among the many claims made by skeptics are that a second shooter fired from behind a grassy knoll, that more than three shots were fired, that Oswald could not possibly have fired his rifle three times within the necessary time frame and certainly not with enough accuracy to hit a moving target, that one bullet could not possibly have wounded both Kennedy and Connally and ended up in Connally's knee, and, finally, that Kennedy's movements when shot prove that the fatal shot had come from in front of him, rather than behind.

In this crime-scene reconstruction, the FBI examiners had the advantage of a home movie of the shooting, taken by a spectator named Abraham Zapruder. Cunningham said that the crime-scene reconstruction began with that film. "We kept going over and over and over the film. Once we started looking at it, we watched it a hundred and fifty times if we watched it once."

"I remember the first time we looked at it," Frazier said. "There were about six or eight of us watching. That first time was pretty rugged because the President's head just explodes. The room was absolutely silent. Then we discovered that there was information on the Zapruder film we saw that didn't appear on the screen when the film was projected. The frame is eight millimeters, and another two millimeters is film that's exposed in the drive wheel—and you can actually see the rest of the picture. You'd be surprised how much information is out in the perforated edge. We had eight-by-tens printed of every frame. In prints you can see a woman standing on the steps of the School Book Depository who doesn't show when it's projected. Or it will show somebody over on the other side taking a picture at a certain point. The way the reconstruction was handled, we got together all the pictures that had been taken that could be located, and using the Zapruder film for timing, we triangulated the car in a particular place at a specific moment. We were trying to pick out when the bullets were fired, where the car was hit, the direction the bullets came from, everything."

Frazier and Cunningham did not investigate the possibility of a conspiracy. They simply examined the evidence they had, and from that reached their conclusions. As for the second assassin supposedly shooting from the grassy knoll in front of the President, Frazier explained, "All this talk about someone seeing a puff of smoke, what they forget is that the charge used in bullets is smokeless powder and the word 'smokeless' means smokeless; it doesn't produce a puff of smoke. It produces a little dark residue possibly, but not like you would take a puff on a cigarette and blow it out."

Key evidence for those people who believe that someone fired at Kennedy from the grassy knoll is the fact that on the film the President's head seemed to jerk backward when he was shot, rather than being driven forward as would seem logical if he was shot from behind. "There's no doubt where the bullet struck the President in the back of the head," Cunningham said. "That frame can be pinpointed."

"And the fact that his head moved backwards can be explained by the jet effect of all the liquid leaving his skull," Frazier continued. "It was like a jet effect created by the material leaving. . . . People say, Well, the motorcycle people behind were all covered with blood and brain tissue. Of course they were. They were moving forward at fifteen miles per hour; this material went up in the air and they drove underneath it. You can look at the President's car and find blood and brain sprayed all over the front windshield and even on the hood of the car."

When President Reagan was shot, a videotape with audio made it possible to prove how many shots had been fired. Zapruder's film did not have sound, and the number of shots witnesses heard was disputed. "They had people who practically heard a machine gun going off," Frazier said. "But there were three people in the Book Depository building on the floor right under Oswald and they said definitely they heard three shots, and they definitely heard cartridge cases hit the floor. And when the shots went off, the floor shook and little particles of sawdust and cement fell down, so they knew where the shots came from."

"Some people [standing outside] underneath the shots said they heard three or four or five shots, but what they were hearing was the crack of the bullet going overhead because it was traveling faster than the speed of sound. They heard the sound of the bullet going overhead and then a half second later, boom, they heard that same shot going off back there in the building. If you hear that second shot, it means you haven't been hit by the bullet. Later, investigators returned to Dealey Plaza and fired a weapon and people heard echoes off the grassy knoll, off the stone work, the railroad embankment. They were hearing reverberations. Eyewitness testimony is not the most accurate there is, and earwitness testimony is even worse."

According to the Zapruder film, the three shots had to have been fired in a minimum time span of 4.8 seconds if the second shot missed, or between 7.1 and 7.9 seconds if either the first or third shot missed. Many people believe that Oswald's rifle simply could not be fired three times within that time span. Frazier and Cunningham disagreed. Frazier, Cunningham,

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and Charles Killion test-fired the rifle for speed and accuracy within days of the assassination. The examiners proved it was easy to fire three aimed shots from Oswald's rifle within any of those time frames. "We fired that gun several times," said Frazier. "Cort fired it, Killion fired it, and I fired it. The minimum amount of time it took me to fire three shots was four point six seconds; the maximum time was six point five seconds. And I wasn't familiar with that gun. The problem with most people is that they forget the clock starts running when you fire the first shot. The cartridge is already in the rifle, you don't have to load it. You're really only loading two shots while you're firing the three. Those two shots had to be fired in a minimum of four point eight seconds, which is twice as long as it takes to shoot carefully aimed shots."

As for accuracy: "This is something that just about every expert has ignored," Frazier said. "The scope of the rifle had been taken off by Dallas police to search for latents, and when we got it, it was loose; we had to tighten the screws down. I think there were shims under the scope when it was used and the Dallas police lost them when they took it off."

"Cort and Killion and I went down to the range and fired at fifteen-yard targets and twenty-five-yard targets and later at hundred-yard targets. At twenty-five yards you could cover our shots with a quarter; at a hundred yards we were within two inches, and the longest it took was six point five seconds. When we tightened the scope we found that it was arranged so that it was shooting a little bit high and to the right. The car was moving, so if you aimed right at the President, then the car would actually move right into the line of fire. If you aimed right at him with the first shot you'd hit low, but with the car moving, the second shot would have hit him the way it did."

Finally, the so-called magic bullet, the "pristine" bullet. This bullet supposedly passed through the President, passed through Governor Connally, hit him in the wrist, and then penetrated into his leg. More than any single piece of evidence, it is the damage attributed to this one bullet that raises doubts about a single shooter. "There's no such thing as that magic bullet," Cunningham said flatly. "Bullets are not predictable. I remember I testified in a case in Baltimore where a man sitting in a bar got into an altercation with someone else, who took out a .22 and shot him right between the eyes. A police officer arrested the shooter and called the ambulance to remove the body. Halfway to the morgue the victim sat up and started complaining that he had a hell of a headache. This bullet struck his skull, went

under his scalp and over the top of his head, and ended up in the back. The doctors took it out, patched him up, and he went back to the bar where the same astonished officer saw him later in the day.

"But you have to understand that in the Kennedy assassination we're talking about military-type bullets which have a solid nose, a jacketed nose, and they're crimped around the base of the bullet. That makes it much stronger, and you get much more penetration with it."

"When the Zapruder film showed the President had been shot," Frazier said, "he was sitting straight up in the car. He'd been waving and he'd just lowered his hand when he got shot in the back. The reason the bullet was squashed was because it went through the President's body and came out through the buttonhole area of his shirt. It just nicked his tie. It didn't hit anything hard next to the backbone, but the pressure would've damaged the central nervous system. That caused the President to jerk up his hands in front of him. In the films you could see he was frozen in that position."

"Connally had been facing forward. When the bullet came out of Kennedy, it was traveling sideways, because the wound in Connally's back was an elongated hole. So the bullet was tumbling when it hit him and it went through him still tumbling, knocked a piece of rib out and came out of his chest. Then it went through his wrist backwards. It had to be backwards because the bullet didn't mutilate and there was lead found in Connally's wrist. And then it buried itself in his leg, still traveling backwards, because when they X-rayed him they found a couple of pieces of lead there. None of this was unusual. It got squashed flat and slowed down. That's why it didn't completely shatter his wrist bone. At the instant of the shot, Connally was facing just exactly right for the bullet to follow a straight line through the President, through Connally's body, to hit his wrist and go into his left leg."

"When we hear this called the magic bullet, we kind of laugh."

Neither Frazier nor Cunningham has ever doubted the conclusions they reached in the days after the assassination. "At first I got angry when I heard these stories," Cunningham said, "but now I just shrug. They start out with a false premise or a 'Let us suppose,' and three pages later, it's no longer 'Let us suppose,' it's a fact. I mean, it would send a logic professor to his grave. It's the most ridiculous thing."

"Same with me," Frazier agreed. "You know they don't have their facts straight, but I'm not going to straighten them out. I almost wrote Walter Cronkite once because he twice made a serious mistake about the amount

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of time it took to fire three shots—they developed a big TV program on that basis—but if they want to do that they will, regardless of what I say.”

“I don’t mean to be insulting to people,” Cunningham added, “but these people are not taking the facts into account, because if their story isn’t sensational, it doesn’t sell books.”

Neither man has seen *JFK*, director Oliver Stone’s movie based on numerous conspiracy theories. And the investigators have read very few of the dozens of books on the subject. “I had to read the first few,” Frazier admits, “because Mr. Hoover said, ‘Read these books and tell me whether they’re right or wrong. Go through it and write in the margins.’ So I wrote a memo saying, ‘He’s wrong here, he’s wrong here, he’s wrong here,’ and then I forgot about it. That’s the way we handled the controversy.”

¶ And finally, when asked the seemingly obvious question—“Was this the greatest case of your career?”—Frazier smiled and said, “When you’re dealing with firearms cases, you get a case of a lifetime every week.”

Hand Evidence by
David Fisher

we magnified it as far as it would go before it started falling apart, and I noticed what appeared to be random spots on the bullet. Some kind of stains. We couldn't do a firearms comparison, there wasn't that much detail, but we could see that the relationship between the stains and lines and grooves on the bullet were exactly the same as we saw on the bullet in custody. That enabled us to show that the coroner had made a simple mistake. It was the right bullet all the time."

Perhaps the most extensively examined blowups in history are those made from the Zapruder film of President Kennedy's assassination. One particularly controversial frame has been interpreted by some people as showing a man mysteriously crouching behind bushes on the grassy knoll overlooking the scene. Other viewers see nothing more than innocent shadow. The lab has looked at the Zapruder film several times since 1963 as photo enhancement technology improved, but as Richards said, "Often making it bigger isn't the answer. What's behind that bush is a lot of skepticism. In many cases this kind of work is like cloud writing. You look up at a cloud and if you wait long enough you can see anything you want to see. You look through those leaf patterns on the Zapruder film and people are convinced that things are there, and in their mind they are. But they're not."

Because people tend to believe things they see with their own eyes, photos are often doctored, or changed. Enlarging and magnifying are among the tools used by photo examiners to help determine if a picture or a document is genuine. The examiner will look for the unusually sharp edges produced by cutting; differences in contrast or brightness; differences in proportion or scale between people or objects; differences in the direction of shadows; background information; even changes in the dot patterns. In perhaps its most controversial case, the lab was asked to determine whether a photograph printed in a Russian magazine in the late 1980s was genuine. It seemed to show two American airmen who years earlier had been listed as missing in action in Vietnam. If the picture was real, it would prove that Americans were still alive and being held captive more than two decades after the war had ended. A private sci-crime lab concluded that the photograph was real. "That was a tough one," Richards admitted. "A lot of people wanted it to be true, but there was no way that could be determined from that photograph. It was a really bad photograph to begin with; it had obviously been copied many times and then it was badly printed in the magazine. We looked at the shadow detail, we looked at the edge detail—they

be the truth, which is very different. Anybody who believes he is telling the truth is going to pass this test." For this reason, anybody—sociopaths, psychopaths, schizophrenics, the toughest prisoners, experienced espionage agents—can be tested, and the results may prove useful in the investigation. And while the results of a polygraph exam are permitted to be introduced in a trial only by prior agreement of both the prosecution and the defense, a confession made during the test is admissible as long as the polygraph exam itself is not discussed.

Rudimentary versions of the modern polygraph have been used by various cultures for thousands of years. Lie detection is based on the fact that people worry about being exposed when they lie, and that fear or anxiety causes measurable physiological changes.

The ancient Chinese made suspects chew dry rice, then spit it out. Fear causes the digestive system to slow down, producing a dry mouth, which in turn makes it difficult for guilty people to generate enough saliva to spit out the rice. Arabs would put a donkey with a greased tail in a darkened tent, then would warn suspects that when the donkey's tail was pulled by a guilty man the animal would bray. Those who emerged from the tent without grease on their hands were presumed guilty.

The very first lie-detecting machine, the hydrophygmograph, was invented in 1895 and measured changes in the pulse rate and blood pressure of a subject being questioned. In 1921 John Larsen developed an instrument that continuously recorded changes in blood pressure, pulse rate, and respiration during questioning; he named this instrument the polygraph.

For a time it was believed to be infallible. It caused banner headlines in the early 1930s when Bruno Hauptmann, the accused kidnapper and killer of Charles Lindbergh's baby, failed a crucial polygraph test. But in 1938, when lie-detector tests given in a Florida kidnapping-murder indicated that an innocent man was guilty and that the person who later confessed to the crime was innocent, FBI director J. Edgar Hoover ordered agents to "throw that box into Biscayne Bay."

The Bureau continued using it on an occasional basis—after Jack Ruby shot Kennedy assassin Lee Harvey Oswald at point-blank range on national TV, he demanded a lie-detector test to prove he did not know Oswald—until 1964, when Hoover banned it from the FBI completely. That proved embarrassing in 1971 when, directed by President Richard Nixon to find the source of leaks of sensitive material from the State Department, the Bureau was forced to borrow polygraph equipment from the New York City police

A polygraph exam is always voluntary. No one can be compelled to take the test. But refusal to take a test does cast doubt on an individual's credibility. When Arkansas state troopers claimed that they had arranged sexual encounters for President Clinton, they offered to take a lie detector test. But when a New York newspaper made arrangements to take them up on that offer, they quickly changed their minds. While the effects of their charges lingered, the story quickly dropped out of the headlines.

Conversely, the fact that a subject voluntarily takes a polygraph test does lend credibility to his or her claims. When figure skater Tonya Harding's estranged husband, Jeff Gillooly, was arrested and charged with plotting an assault on Harding's rival Nancy Kerrigan, prior to the 1994 Winter Olympics, Gillooly decided to make a deal with prosecutors by implicating Harding in the plot. As a prerequisite for any agreement, the prosecutors wanted Gillooly to take a polygraph exam. The questions focused on whether Gillooly was telling the truth when he said that Tonya Harding was aware that there was going to be an assault on Nancy Kerrigan and had approved the plan. When Gillooly passed the test, the focus of the investigation shifted to Harding, who eventually confessed her involvement in the bizarre plan to keep Kerrigan out of the Olympic games.

While the question-and-answer phase of a polygraph test is always straightforward, examiners have been known to use a variety of techniques to convince subjects to tell them the truth. When two suspects in the same crime are being interviewed in separate rooms, for example, the examiners will often play them against each other. They might have a pizza delivered to one room and nothing to the other, and let the second suspect draw the obvious conclusion from that. Or they might use bits of information obtained in one interview to convince the second suspect that they know more than they really do. And finally, they might simply say, "We really don't need to spend any more time here. Your partner told us that he got the watch and the wallet, but that you did the shooting. So we're going to take a statement from him." It's all legal, as long as the subject is not coerced into making a statement, or told what to say. Then it's up to the machine to determine if he is telling what he believes the truth to be.

The roster of cases in which the polygraph has been used to verify information, develop investigative leads, or clear innocent people reads like the history of crime in modern America. One of the most dramatic exams in recent history was that given to Jack Ruby, the man who shot and killed Lee

Harvey Oswald before Oswald could be questioned about the assassination of President Kennedy.

Oswald's murder is the pivotal point in just about every Kennedy assassination-conspiracy theory. According to many of these theories, Ruby knew Oswald and killed him to prevent him from revealing details of the plot to kill Kennedy. Ruby vehemently denied this until the day he died of cancer, and demanded the opportunity to prove, by taking a polygraph exam, that he was telling the truth. The Warren Commission charged with investigating the assassination finally acceded to Ruby's pleas, and Special Agent Bell Herndon was assigned to conduct the test. The test took place in Dallas, Texas, on July 18, 1964. "I'd been working right along on various aspects of the assassination; just about everybody in the lab was," Herndon recalled. "Oddly enough, what I remember most were the President's shoes. They were very old and very worn, they'd probably been resoled several times, but they were so well polished. So by the time I interviewed Ruby, the exam was just another aspect of the case.

"I prepared the questions with several people, including Arlen Specter, later to become a senator from Pennsylvania but then a lawyer working for the Warren Commission. We formulated questions for Jack Ruby to see if we could get to the crux of the matter. Did Ruby know Oswald? Was Ruby involved in a conspiracy? Was there premeditation on the part of Ruby and Oswald to get together to do something about President Kennedy? Was Ruby possibly linked to an organized-crime element out of Chicago and paid off to silence Oswald? Was there a conspiracy? Was Ruby paid off by the Mafia? Was Ruby a member of the Communist party? We were aware of all the theories going around and we tried to cover them all in my interrogation.

"The test was very lengthy, which I objected to, and I do think there came a time when Ruby was desensitized. He was showing some fatigue. When the test began I tried to establish a rapport with him. I felt like I had the best chance with him if I treated him very respectfully, if I was very sympathetic, if I didn't make him feel like he was a subject, but rather just an individual trying to clarify his involvement in the assassination. I didn't want to be the heavy, which is sometimes necessary when you're sitting down with a hardened criminal and you have to dominate the situation.

"I think I was probably correct, because Ruby was cooperative. He seemed to understand the intent of the questions, he didn't move, he didn't fidget, and he answered the questions as he was instructed. I think

that Mr. Ruby felt that by taking this test, by being candid and cooperative, he could convince the world that he shot Oswald because he was so mad that Oswald had killed our beloved President. The one question I never asked him was, 'Did you shoot Lee Harvey Oswald?' because that was pretty well resolved. He'd done it on national television; it just was beyond being a relevant question.

"I've always considered the polygraph to be a scientific interrogation technique, but there's more to it than the machine. The Bureau's position is that subjective impressions by the interrogator are just as valuable as what the chart or pen tracings show. I always look for body language, eye expressions, nervousness, whether he's deliberately trying to defeat the machine by flexing his muscles or by moving, clearing his throat; it's all part of an innate sense a good interviewer gets after conducting years of exams.

"I believed Jack Ruby when he told me he did not know Oswald and that he was not part of a conspiracy. I had asked him several control questions where I knew he was not telling me the truth, but I didn't see that same kind of reaction to the relevant questions that I asked him. There was also a question of Ruby's mental stability. His doctor was present because I had been warned that maybe Ruby was not quite what we would call fully sane. But he appeared to be physically fit to me, and he wasn't under any medication.

"My conclusion was that he was a valid subject. I felt that although maybe he had some mental aberrations, and who wouldn't in his situation, I thought that there was no indication of deception to relevant questions. But I also stated that if a doctor said that this man was a manic-depressive, I wasn't going to be foolish enough to contradict him. And if that were true, then I would have to render my conclusion nonconclusive. But on that day, I felt he understood the intent of my questions, that he was not divorced from reality and he was fully cooperative, and that he was telling the truth as he believed it to be."

Is it possible to beat the machine? To get away with deception? Absolutely. The Russians, Cubans, Bulgarians, and other former Eastern bloc countries had extensive programs in which they taught their agents and military officers various ways of handling a forced polygraph exam. Because Eastern bloc nations did not commonly use the polygraph, our government did not have such a program. But in one instance an American operative moving freely between West and East Germany was accused by the East Germans of working for American intelligence and given a polygraph test.

— THE ONE AND ONLY —

mated searches were rarely attempted and even more rarely successful. The art of fingerprint identification entered the computer age in 1968, when a rudimentary computer was used for the first time to assist in identifying the man who had assassinated Martin Luther King, Jr.

When Dr. King was murdered in Memphis, Tennessee, in 1968, detectives found latent prints on the rifle from which the fatal bullet was believed to have been fired, and on a pair of binoculars. When investigators find only a single print or a fragmentary print, it's very difficult to figure out which finger left that print. Sometimes that can be determined from the location of the print on the object. For example, people generally rip paper by holding it between their thumb and forefinger, so when a print is found on torn paper, it's generally assumed to be either a thumb or forefinger. In this case, because of the position as well as certain other characteristics, the prints were identified as that of the killer's left thumb. As Specialist Bobby Erwin explained, "We had a left thumbprint, we had the alias the killer had used when he checked into the hotel—'Eric S. Galt,' I believe it was—but we had nothing to match that print to. We needed a real name so we could find a card in our files.

"Memphis police and federal agents had developed a lot of suspects right off. But we just couldn't make a match. The police tracked this Galt to shoddy hotel rooms in several states, and we got a lot of paper items—newspapers and maps—and we developed more prints from those. We got one good print off a map found in a flophouse in Atlanta, identical to the prints found on the rifle and binoculars, that gave us a lot more detail."

Investigators checked the prints of known members of subversive groups like the KKK and the Minutemen, but were unable to make a match. With no other suspects, it was decided to compare that latent print to those of all current fugitives known to the Bureau. This turned out to be about 53,000 people. "But we had a physical description of the assassin and an identifiable thumbprint," Erwin pointed out, "so we asked our people, 'Can we narrow it down by physical description and a description of the type of print in the number six finger?' Using that information they conducted a computerized search and successfully narrowed it down to nineteen hundred individuals.

"Then we requested that the assembly section pull all those cards a hundred at a time and we were just going to sit there and go through them one by one. It was less than a needle in a haystack, because we didn't even know if the needle was there. So they brought the first hundred cards and I

— Ident/DNA —

started going through them and I looked at the fifth card and there it was. The fifth card. I didn't have to compare it to our latent thumbprint. I'd looked at that print so often it was embedded in my mind. I saw this one and I almost fell out of my chair. The funny part of it was that the assistant supervisor, Dan Bailey, sat right across from me and at times during the search, just to shake things up, I'd say every once in a while, 'Hey, Dan, I got the guy.' He'd get excited and I'd confess I was kidding. This time though, I looked at him and said evenly, 'Dan, I got him.'

"He didn't believe me. 'I'm not kidding,' I said, 'I got him. It's him.' The fifth card. I handed the card to him and he just stared at it, then said softly, 'By God, it is him. Here goes the ball rolling.' That's how we finally identified James Earl Ray as the man who killed Dr. King."

Ray's prints were in the fugitive file because he had escaped from a Midwestern prison where he was serving time for robbery. He eventually pleaded guilty to Dr. King's murder and was sentenced to ninety-nine years in prison.

The procedure used to identify Ray has become far more sophisticated. Once it's determined which finger or fingers made a latent print, a computer search can be conducted. Prints are stored in the computer on the basis of the unique identifying characteristics found in a small portion of the center of the finger. The computer has a sort of digital map of that part of the finger. Obviously, the ability of the computer to identify an unknown individual by matching a latent print increases tremendously when additional information about the suspect is available, for instance his height or race, enabling investigators to be more specific in their search.

This system can be very effective. When an off-duty Harrisburg, Pennsylvania, policeman was murdered, his stolen van was spotted in Virginia. After a wild shootout on a highway, the killers escaped and abandoned the van in North Carolina. Several days later a van stolen from the North Carolina town in which the policeman's van had been recovered was found in Tallahassee, Florida. The same prints were found on both vans. Using a partial description of the killers, the Latent Print Section ran an automated search for those prints—and scored a hit. One of the killers, positively identified through his prints left on the vans, was subsequently convicted of the murder.

Every comparison between a latent print and a known print is done pretty much the same way, whether prints are being compared to try to find Martin Luther King's killer, or to identify putrefying remains from Jones-

— NUMBER ONE WITH A BULLET —

the bullets that killed Dr. Martin Luther King, Jr., were proved to have the same rifling characteristics as a rifle found nearby, fingerprints found on that rifle eventually led to the identification of the assassin, James Earl Ray.

A bullet makes a fuss. It leaves plenty of information in its wake, and finding and interpreting that information is the basis of sci-crime ballistics. It's the work of the Firearms Unit, and it is one of the oldest applications of science to crime solving.

The proliferation of guns in America is a subject of great controversy. Guns have become the primary means of murdering human beings in this country, and the issue of gun control has become a central focus of American political debate.

Firearms examiners don't take sides in this debate, at least not officially. By the time sci-crime investigators get involved the weapon has already been fired, the victim has been shot. Their work is devoted to answering one question: Who pulled the trigger?

The use of a bullet to connect an individual to a crime dates back to 1835, when a member of London's Bow Street Runners, the predecessor to Scotland Yard, was able to match a ridge found on a bullet removed from a victim's body to a gouge in a bullet mold found in a suspect's home. When confronted with this evidence the suspect confessed to the shooting, and the science of ballistics was born. The first recorded firearms case in America took place in 1879, when a man charged with murder was acquitted after a gunsmith testified that the suspect's gun hadn't been fired in more than a year. In a 1902 murder trial, Judge Oliver Wendell Holmes enlisted the services of a gunsmith to determine if the fatal bullet had been fired from a suspect's gun. The gunsmith fired several shots from the weapon into a basket of cotton, then used a magnifying glass and microscope to show the jury that marks found on the fatal bullet were identical to marks on the test bullets. Thus he proved that this gun had been used in the murder, proof that led to the suspect's conviction.

Basically, that's still the way firearms examinations are conducted. The equipment has become a lot more sophisticated, but the premise is exactly the same: bullets fired from the same gun will exhibit many of the same unique characteristics. So by comparing a bullet fired in a crime to a bullet fired in a test, investigators can prove that a specific weapon was used in the commission of that crime.

Almost every firearms case handled in what is officially known as the Firearms and Toolmarks Unit begins with the submission of a gun or bul-