The Evolution of Fire Investigation and Its Impact on Arson Cases

BY JOHN J. LENTINI

The first step in investigating an alleged arson fire is to make certain that the fire was, in fact, intentionally set. Except in the most obvious cases, this step requires expert assistance from a knowledgeable fire investigator. Unfortunately, many practicing fire investigators in the United States today are not knowledgeable, and this has led to several high-profile miscarriages of justice. Ernest Ray Willis served 17 years on death row in Texas for setting a fire that was, in all probability, an accident. Willis was granted a new trial based on *Brady* violations and ineffective assistance of counsel, and when he reviewed the science, the new prosecutor declined to retry the case. (Willis v. Cockrell, No. P-01-CA-20, 2004 U.S. Dist. LEXIS 15950, *2 (W.D. Tex. Aug. 9, 2004).) Cameron Todd Willingham was not so lucky. (Willingham v. Dretke, 540 U.S. 986 (2003) (*cert. denied*).) He was executed after 12 years on the same death row based on "expert" testimony that was described by a consul-

tant hired by the *state* as "hardly consistent with a scientific mindset and [is] more characteristic of mystics or psychics." Other high-profile cases that have been chronicled recently include Amanda Hypes of Louisiana, who was wrongly accused of setting a fire that killed her three children, and Kristine Bunch of Indiana, who was wrongly convicted (and is still serving time) for setting the accidental fire that killed her young son.

Dozens of other innocent citizens have been wrongly convicted of arson, but there is no DNA to set them free. Postconviction relief is rare, but seems to be happening more frequently in arson cases. James Hebshie in Massachusetts had his conviction vacated based on ineffective assistance of counsel, and the government declined a retrial. (United States v. Hebshie, 754 F. Supp. 2d 89 (D. Mass. 2010).) George Souliotes in California won an evidentiary hearing based on new science/new evidence and a claim of actual innocence. (Souliotes v. Evans, 622 F.3d

1173 (9th Cir. 2010).) Daniel Dougherty, who currently resides on death row in Pennsylvania, won an evidentiary hearing based on ineffective assistance of counsel. (Commonwealth v. Dougherty, 18 A.3d 1095 (Pa. 2011).)

This article describes the changes that have had an impact on the fire investigation profession over the last three decades. Although change has been gradual and at times maddeningly slow, the pace of change has stepped up even as our knowledge of fire behavior makes us less certain about the accuracy of fire origin and cause determinations. Criminal justice professionals should be aware of the changes in the science, to enable them to decide whether to go forward with the prosecution, mount a defense, or challenge evidence based on its reliability or lack thereof.

The Investigators

Fire investigation is a complex endeavor that requires practitioners to make numerous sophisticated decisions involving chemistry and physics. It would be wonderful if all fire investigators were up to the task, but society has elected not to reward fire investigators for obtaining the fundamental knowledge required to do their jobs. Salaries for public sector investigators are often insufficient to attract college graduates. Most public sector investigators get their training "on-the-job" where the belief systems of their seniors are passed down. Certainly it is possible for individuals with no chemistry or physics beyond high school to apply themselves and learn the basic science, and keep up with developments in the field. But funds for such training are limited.

The reality is that the fire investigation profession has within its ranks a large number of individuals who don't know what they're doing, and are blissfully unaware of the work of fire scientists who have been trying for years to get across the crucial point that *fire patterns must be interpreted differently* when the fire has fully engulfed a room. The only word for such individuals is "hacks." Hacks work cheap and they work quickly, but when they make an arson determination, it will often fail to withstand even mild scrutiny.

There are methods available for identifying who is a hack and who is qualified to do this important work. One hopes that this vetting of the fire expert is accomplished by the prosecutor prior to bringing a case, and by defense counsel prior to hiring an expert. It has been held in the Sixth Circuit that in a fire case where the cause is contested, the assistance of a *competent* expert is

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an essential component of effective assistance of counsel. (Richey v. Bradshaw, 498 F.3d 344 (6th Cir. 2007).) There now exists a standard for professional qualifications for fire investigators, which applies equally to public and private sector investigators:

1.3.7* The fire investigator *shall* remain current with investigation methodology, fire protection technology, and code requirements by attending workshops and seminars and/or through professional publications and journals.

1.3.8* The investigator *shall* have and maintain at a *minimum* an up-to-date basic knowledge of the following topics beyond the high school level at a post-secondary education level:

(1) Fire science
(2) Fire chemistry
(3) Thermodynamics
(4) Thermometry
(5) Fire dynamics
(6) Explosion dynamics
(7) Computer fire modeling
(8) Fire investigation
(9) Fire analysis
(10) Fire investigation methodology
(11) Fire investigation technology
(12) Hazardous materials
(13) Failure analysis and analytical tools

(NFPA 1033, Standard for Professional Qualifications for Fire Investigator (2009) (emphasis added).)

The basic knowledge required by *NFPA 1033* can be found in another publication, *NFPA 921, Guide for Fire and Explosion Investigations*. Although not widely embraced when it was first published in 1992, subsequent editions are now frequently cited in court decisions about arson cases, and it is generally regarded as the standard of care. Both *NFPA 921* and *NFPA 1033* should be required reading for any attorney who hopes to effectively present or defend a case involving fire.

It is quite a simple matter to put together a small "quiz" to see if a fire investigator knows the definition of "thermodynamics" or "fire science," or if he or she knows enough fire chemistry to describe the combustion of hydrogen. An investigator who has failed to maintain "an up-to-date basic knowledge" of these topics is someone who does not need to be investigating fires. It is embarrassing when your investigator "eliminates" a gas fire, but does not know that natural gas is mostly methane or that the chemical formula for methane is CH_4.

Reading an investigator's report is another way to tell

ACCELERANT-DETECTING CANINES

In 1982, the Bureau of Alcohol, Tobacco, and Firearms (ATF) pioneered a program to bring trained canines into fire scenes to aid in the detection of ignitable liquid residues. These "accelerant detection canines" (ADCs) are a valuable tool to assist fire investigators in selecting samples that have a high probability of testing positive when submitted to a laboratory. Unfortunately, this tool has been misused over the years, and despite the scientific community's disparagement, the use of dogs in the courtroom continues. (*See, e.g.*, United States v. Hebshie, 754 F. Supp. 2d 89 (D. Mass. 2010) (Judge Nancy Gertner's order to vacate conviction).)

In 1994, a group of scientists (including this author) on the International Association of Arson Investigators Forensic Science Committee developed a position paper that stated that an ADC alert might be acceptable in the context of finding probable cause to look further, but that no jury should ever hear about an unconfirmed canine alert. This position was ratified by the National Fire Protection Association (NFPA) in 1996, when an emergency amendment was added to *NFPA 921*, so that courts could be advised that unconfirmed canine alerts did not constitute valid science. This seemed to reduce the use of unconfirmed canine alerts in arson cases, at least for a while. The Georgia Supreme Court in 1996 overturned Prosecutor Nancy Grace's last conviction because she had used 12 unconfirmed canine alerts as evidence in the case against Weldon Wayne Carr. (Carr v. State, 482 S.E.2d 314 (Ga. 1997).)

When the NFPA addressed the subject in 1996, the Technical Committee on Fire Investigations wrote, "The committee, as specially trained members of the scientific, engineering and fire investigative community, know that evidence and testimony relied upon by our nation's courts have been empirically proven to be false. In essence, a fraud is being perpetuated upon the judicial system." The statement is as true today as it was then. But today, the lessons of the 1990s seem to have been lost on some prosecutors and fire investigators who are once again trying to persuade juries that dogs are more sensitive than laboratories, and that unconfirmed alerts by a dog that cannot be cross-examined, constitute relevant evidence. It is neither relevant nor reliable, but some trial court judges let these unconfirmed alerts into evidence anyway.

Consider the case of drug-detecting and explosive-detecting canines. If a canine trained to detect drugs alerts on a suspect's briefcase, but no drugs are found, no charges for possession of drugs are brought. If a canine trained to alert to explosives alerts to a traveler's suitcase, and no bomb is found, no charges for possession of explosives are brought. The only difference between accelerant-detecting canines and drug- or explosive-detecting canines is that unconfirmed ADC alerts are sometimes allowed as evidence. Some fire investigators hold to the belief that "Dog said it. I believe it. That settles it."

Laboratories today are capable of detecting 0.1 μL (1/500 of a drop) of ignitable liquid residue in a gallon of fire debris without breaking a sweat. If the laboratory is unable to find any ignitable liquid residue, having the dog handler testify that "There really was something there but the laboratory missed it," has the potential for setting up a gross miscarriage of justice. Such unconfirmed alerts should not be put forward by prosecutors, and if they are, defense counsel should object most strenuously. And the judge should not allow such witchcraft to be presented to the jury.

—John Lentini

if an investigator is qualified. Incendiary fire classifications based on fires that burned "hotter than normal," or based on concrete spalling or a melted aluminum threshold, or based on an unconfirmed canine alert, or based on any of the mythology that has been discredited by *NFPA 921* are likely to be incorrect. Basing a prosecution on such a report is likely to set the stage for a miscarriage of justice.

The first serious challenge to the "old school" of fire investigators came in 1996 in *Michigan Millers Mutual Insurance Corp. v. Benfield*, 140 F.3d 915 (11th Cir. 1998) (*available at* http://tinyurl.com/82c3d86), in which a fire investigator who failed to properly document his observations was excluded from testifying. In the appeal of that exclusion, the International Association of Arson Investigators (IAAI) filed an amicus brief, in which it contended that fire investigators should not be held to a strict reliability inquiry because fire investigation was "less scientific" than the kind of scientific testing discussed in *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579 (1993). Eventually though, there were enough court rulings, including the unanimous Supreme Court decision in *Kumho Tire Co. v. Carmichael*, 526 U.S. 137 (1999), to persuade the majority of fire investigators that it was necessary to accept the scientific method recommended by *NFPA 921*.

It is difficult to state exactly when *NFPA 921* became "generally accepted by the relevant scientific community," but 2000 was an important turning point. That year the United States Department of Justice released a research report entitled *Fire and Arson Scene Evidence: A Guide for Public Safety Personnel*, which identified *NFPA 921* as a "benchmark for the training and expertise of everyone who purports to be an expert in the origin and cause determina-

tion of fires." That same year, the IAAI for the first time endorsed the adoption of the new edition of *NFPA 921*.

Currently, most fire investigators will acknowledge that the scientific method is the only valid analytical process by which one can reach reliable and accurate opinions and conclusions regarding the origin and cause of a fire. There are some, however, who neither understand nor follow the scientific method.

A More Cautious Approach

One thing that *NFPA 921* has accomplished is to make it easier to distinguish between credible investigative results and those based on hunches and feelings or discredited mythology. The guide provides the investigator with the tools to do his or her job, but demands that conclusions be justified with data, sound science, and clear reasoning. This is a good result. Based on my 35 years of studying fires, including more than 2,000 actual fire scene inspections (about 800 of which I determined to be arson) I learned two important things: most fires are accidents, and most arson fires are obvious. Surely there are exceptions, but if a fire investigator over and over again reports an incendiary determination that seems difficult to understand, chances are this investigator needs to find another line of work in which the consequences of error are not as serious.

Nationwide, from 1999 to 2008, the National Fire Protection Association (NFPA) reported a drop from around 15 percent to around 6 percent of fires determined to be arson. A study in Texas showed a drop of 60 percent in arson fires between 1997 and 2007. (Dave Mann, *Fire and Innocence*, Texas Observer, Nov. 27, 2009.) A similar study conducted in Massachusetts had even more startling results. Between 1984 and 2008, the percentage of arson fires in the state dropped from more than 20 percent to less than 2 percent, despite a net increase in the total number of fires. (Jack Nicas, *Another Arson Conviction Challenged*, Boston Globe, Sept. 8, 2010.) Statistics can be slippery, but the clear trend in all of these studies is downward. Mann attributed the change to fire investigators making fewer mistakes, while Massachusetts State Fire Marshal Stephen D. Coan attributed it to more fire education, visibility of law enforcement, and successful prosecutions. Both views seem a little extreme. One other factor to take into account is the changing terminology of fire and arson investigation. The National Fire Incident Reporting System documents formerly included a category called "incendiary or suspicious." The term "suspicious" has now been dropped at the urging of the NFPA Technical Committee on Fire Investigations, so fires are less likely to be reported as incendiary, even if a fire investigator happens to harbor some suspicions.

But surely, at least some of the downward trend can be credited to fire investigators taking a more cautious approach, and being more cognizant of the consequences of their determinations. This caution is probably *not* the result of old-school fire investigators changing their ways. *NFPA 921* has now been a fact of life for 20 years, a time period during which many poorly trained investigators have had the opportunity to retire, and new fire investigators have always been aware of the need for more caution.

The New Science of a Post-Flashover Burn

As the great scientist Max Planck put it, "Science advances one funeral at a time." New ideas tend to spend a fair amount of time in the "heresy box"; new ideas in fire investigation are no exception. When it was first posited in the mid-1980s that full-room involvement could cause the production of "puddle shaped" areas of charring on a floor in the absence of a liquid accelerant, many fire investigators derided that idea as "the flashover defense."

Flashover is a transition that takes place in a structure fire. It is a phenomenon that most people are not familiar with, because it does not happen with outdoor fires. The concept that "heat rises" is familiar to everybody, but indoors, the heat only rises until it reaches the ceiling. When the fire undergoes flashover, it is said to make the transition from "a fire in a room" to "a room on fire." Prior to flashover, a fire grows by involving more fuel. Once flashover occurs, all of the fuel that can be involved is already involved, and the fire can only grow where it has sufficient ventilation. The fire is said to have made the transition from a "fuel-controlled" fire to a "ventilation-controlled" fire.

It was only when fire investigators began allowing their weekend seminar training fires to continue for a few minutes after flashover that they began to realize what the fire protection engineers were saying was correct. It's important to understand that the rules for interpreting fire damage change once the fire becomes fully involved. There is still a small but significant cadre of fire investigators fighting a rear-guard action who refuse to accept this fact, but acceptance is coming. The best training that fire investigators receive no longer focuses on teaching them to "recognize arson," but on teaching them how to understand fire patterns, particularly the effects of ventilation on post-flashover fires.

In 2005, a group of certified fire investigators from the Bureau of Alcohol, Tobacco, and Firearms (ATF) designed an experiment that mirrored similar experiments that had been conducted (but not documented) at the Federal Law Enforcement Training Center in Glynco, Georgia.

Two 12x14-foot bedrooms were set on fire and allowed to burn for about two minutes after they flashed over. The investigators then asked 53 participants in a Las Vegas IAAI-sponsored fire investigation seminar to walk through the burned compartments and determine in which quadrant they believed the fire had originated.

RELIABILITY OF COMPUTER FIRE MODELS AT TRIAL

There are many processes taking place simultaneously in a structure fire. Energy is being released by the burning fuel and transferred to the surrounding fluids (air and smoke) and solids in the environment. The temperature of the room is increasing. A fire plume is carrying the products of combustion upward, and a hot gas layer forms and then grows deeper. The gas layer radiates energy onto other fuel packages in the room and conducts energy into the walls and ceiling. Chemical bonds are being broken and new ones are being formed. The concentrations of gaseous species in the room are changing as oxygen is consumed and carbon dioxide, carbon monoxide, water, and other combustion products are generated.

A model is an attempt to use quantitative information to mathematically describe how some or all of these processes will change over time under specific conditions. Fire modeling is a relatively new discipline based on the idea that fire might be studied numerically. The algebraic models are known as "hand" calculations or correlations. The more complex models use multiple differential equations (calculus), which must all be solved simultaneously by using numerical methods. This requires a computer, as well as the ability to describe the structure and its contents on a three-dimensional grid.

Fire models were not initially designed to be used in fire investigations. They were developed by fire protection engineers largely as a means to avoid actual fire testing. Some fire protection engineers will state (not entirely in jest) that in the twenty-first century, their whole reason for existence is to eliminate the fire resistance test. Fire models are the means to that end. Of course, live fire tests are necessary to validate any fire model.

The National Institute of Standards and Technology has used models to assist fire investigations, including major events such as the Station nightclub fire, in which 100 people died, the Cook County Administration Building fire, and the World Trade Center attacks. Models can be useful in developing or testing hypotheses, but care must be used in their interpretation. As with any computer simulation, the GIGO (garbage in, garbage out) rule applies. Models require the use of assumptions and approximations. More complex models make fewer simplifications but require more data input. If an incorrect assumption is used or a parameter is incorrect, an incorrect answer is the likely result.

The proper use of the model is to propose an ignition scenario and then run the model forward in time to see if the model accurately predicts the outcome. One of the best uses of a fire model is to test the effects of changing a significant parameter by asking "what if" questions. What if we had sprinklers in place? What would have happened if the stairwell door had not been propped open, or the smoke detector had batteries in it, or if the interior finish had been fire-resistant drywall instead of plywood paneling? A model does *not* take the post-fire artifacts and run the fire in reverse to find the origin.

Answers that a fire protection engineer might consider to be "in relatively good agreement" may be too imprecise to address questions in the context of a fire origin and cause investigation. The uncertainty associated with the predictive abilities of models is their principal drawback. While the measurements taken in actual fire tests can have uncertainties of up to 30 percent, real tests involving real fires still have more credibility than computer models in some quarters. Confronted with a computer model that predicts a fire resistance of two hours for an architectural assembly, a fire official might demand proof that the model is valid. Confronted with a hypothesis that a fire began or spread in a particular way based on a model, a party to fire litigation might ask for similar proof.

If an investigator were to conduct five identical fire experiments, the value for any given variable (temperature, CO concentration, smoke density, etc.) at a particular point in space and time would vary from test to test; and if enough tests were run (a very expensive proposition), the "error bars" for each value could be determined, assuming accurate measurement capabilities. If the investigator puts the same data into a computer model, however, only one value comes out. Both computer modeling programs CFAST and FDS come with the following disclaimer in their user manuals: "The software package is a computer model that may or may not have predictive capability when applied to a specific set of factual circumstances. Lack of accurate predictions by the model could lead to erroneous conclusions with regard to fire safety. All results should be evaluated by an informed user."

The definitive guidance for selecting and using models to answer questions about a fire can be found in the Society of Fire Protection Engineers (SFPE) *Guidelines for Substantiating a Fire Model for a Given Application*.

What does the availability of models mean for the fire investigator? That depends entirely on the nature of the question that the fire investigator asks. A model will not locate the origin of the fire, nor will it determine the cause. There has been a disturbing trend for fire investigators to use hand models or spreadsheet calculators such as a CFI calculator in inappropriate ways. Models simply do not have the ability to resolve many issues that concern the fire investigator.

For example, when fire protection engineers are designing a sprinkler system, they have the option of using a model to help them, but they do not base their fire safety engineering decisions entirely on the output of the

model. It is a relatively simple matter to over-engineer the system, so that if the model states that 10 sprinkler heads will do the job, 15 might be put into the final design. Similarly, some fire investigators estimate the heat release rate required to bring a room to flashover using models, then they estimate the heat release rate of a proposed single fuel package, and if that package is "insufficient," these investigators will declare that there must have been two or more points of origin.

If there is insufficient physical evidence on the fire scene to reach a conclusion as to the origin and cause of the fire independent of the model, relying on the model to answer these questions is invalid and irresponsible. It almost goes without saying that fire determinations based on modeling should be challenged. The model was simply not designed for that application. Examples of "successful" modeling often include a comparison of the output of the model with a videotape of the actual fire. The Station nightclub is a good example of such a success story. The only reason that the model can so successfully mimic the videotape is that the videotape existed. The first time the model was run, it predicted flashover in less than six seconds. Repeated iterations of data entry were required to get the model to agree with the videotape. If there is insufficient evidence at the fire scene to even formulate a testable hypothesis, the model output amounts to nothing more than computerized speculation. People are impressed with numbers, but the mere circumstance that data can be quantified and manipulated is no guarantee that the results will portray anything real.

An interesting comparison of model predictions versus real world fire behavior was conducted in 2006 in Scotland. Ten teams of modelers were asked to predict fire behavior in a typical apartment in a high-rise building. The modeling teams were provided with more information than is typically available to a modeler investigating a real world fire, but unlike many other comparisons of model "predictions" versus actual fires, the modeling teams were not given much of the experimental data. They were asked to predict time to flashover and upper layer gas temperature, among other parameters. The predictions varied widely from each other and they varied widely from the experimental results. The authors of the study reported "the accuracy to predict fire growth (i.e. evolution of the heat released rate) is, in general, poor." (Guillermo Rein et al., *Round-Robin Study of a priori Modelling Predictions of the Dalmarnock Fire Test One*, 44 Fire Safety J. 590, 590 (2009), *available at* http://tinyurl.com/7tynlvz.) The authors stated that with a lot of labor, a model's output could be made to fit the post-fire artifacts when those were already known to the modelers, but the track record for actual prediction was not good.

While modeling is an interesting tool, it is, in this author's view, "not ready for prime time" concerning fire investigation, and not sufficiently reliable to be admitted into evidence. One New York court has already ruled this to be the case, with the justice making the following points:

- [C]omputer fire modeling, when used to determine the cause of a fire, would be novel for that purpose and is not generally accepted in the fire investigative community.
- [T]he expert has not demonstrated its general acceptance in fire investigation.
- Although defendant's expert may support a case for the acceptance of computer fire modeling in the regulatory/design community, it does not support a conclusion that it is generally accepted in the fire investigation community.

(Santos v. State Farm Fire & Cas. Co., 905 N.Y.S.2d 497, 499–501 (2010) (Phelan, J.).)

One can use models to make conservative engineering decisions, but using it to "predict" the behavior of a particular fire is likely to lead to error. Until models can be shown to accurately describe what is going to happen without the modeler being provided with a videotape of the fire from its ignition until its extinguishment, the output of any model should be viewed with extreme skepticism, and challenged accordingly. If the classification of the fire cannot stand on its own without the use of a model, then the classification should remain undetermined.

—John Lentini

In the first compartment, only three of the 53 participants correctly identified the quadrant. When repeated in the second compartment, again, only three participants identified the correct quadrant.

These results caused much consternation, demonstrating as they did that the favored method of locating the point of origin of a post-flashover fire by relying on the "lowest burn and deepest char" was unreliable.

Yet the "lowest and deepest char" is still the most often cited data used to support a fire investigator's origin determination. Although it may seem reasonable that the charring will be greatest where the fire burned the longest, that is simply not true for fully involved fires, and such determinations are ripe for a reliability challenge.

An error rate over 90 percent shocked many, but the poor results should not have surprised anyone. In the undoc-

umented tests at Glynco, the success rate was 8–10 percent. (Steven W. Carman, Senior Special Agent, ATF, Improving the Understanding of Post-Flashover Fire Behavior, Address at the International Symposium on Fire Investigation Science and Technology (May 2008), *available at* http://tinyurl. com/6uhp6gu.) Even taking into account that participants in the Las Vegas tests were not allowed to perform other activities that typically take place at a fire scene, and that many of them had less than stellar qualifications (some being there simply to familiarize themselves with fire investigative procedures), there's no way to increase the number of correct origin determinations beyond three out of 53. In the end, the fire patterns definitely misled most of the investigators, whose professed expertise was "reading fire patterns."

In an attempt to understand what was going on, the ATF agents recreated the test fires at the ATF Fire Research Laboratory in Maryland, modeling the results using computational fluid dynamics. (See sidebar, *Reliability of Computer Fire Models at Trial*). What came out of these studies was a better, but certainly not complete, understanding of the effects of ventilation in post-flashover fires. The results of these studies have now been incorporated into two very well produced training modules, available at no cost at www.CFITrainer.net. Even nonscientists can understand these modules.

The Importance of Origin

The principal problem with determining the wrong origin is that the ignition source will not be found there. Finding an origin without an accidental ignition source will lead investigators who don't understand fire dynamics (defined as the study of how fire chemistry, fluid mechanics, and heat transfer interact to influence fire behavior) to conclude that somebody must have placed some fuel at that origin and ignited it with an open flame. If there is an irregular burn pattern on the carpet in that area, even in the absence of a positive laboratory report, the investigator will almost certainly conclude that the fire was intentionally set using a flammable liquid. Many investigators have made errors using this kind of "negative corpus" determination. Finding the correct origin is the key to a correct fire cause determination, and is the most difficult part of the investigation of a fully involved compartment fire.

In 2007, ATF agents refined and repeated the Las Vegas experiment in Oklahoma City. They set up three burn cells, with identical fuel and identical ventilation, but different points of origin. The cells were allowed to burn for 30 seconds beyond flashover, 70 seconds beyond flashover, and 180 seconds beyond flashover. To put these times in context, the best fire departments in big cities *might* have a three-minute response time. If they are not called until someone sees the fire venting out the window (a sign of flashover), the chances of them extinguishing the fire with less than three minutes of post-flashover burning are practically zero. The results of the Oklahoma City experiment validated the data from Las Vegas. Further, it became clear that the longer the fire was allowed to burn after flashover, the less likely the fire investigators were to correctly identify the quadrant of origin.

Of those 53 investigators who did respond, only 25 percent got the quadrant of origin correct. While this is a better than the 6 percent obtained in Las Vegas, it is no better than would be expected if the investigators had chosen the quadrant of origin at random. And there are those who would argue that even 84 percent correct would be a low number when one is using those determinations to send people to prison.

What these results show is a fundamental unreliability of many fire origin determinations. What these results also show is that fire investigators—and the people who use them as experts—need to be prepared to accept the reality that sometimes the best answer that can be obtained is "undetermined," if either an accidental or an incendiary call is not supported by conclusive evidence.

Preventing and punishing arson is an important function, but it is one that is not as simple as it was in the past. New knowledge about fire behavior—and particularly about the difficulty in correctly determining *where* a fire that burned beyond flashover started—has placed new burdens on those charged with investigating fires. Agencies that accept these responsibilities will have a credible deterrent effect on arson. As long as there are those who provide support to the hacks, however, horror stories about wrongful prosecutions and convictions will undermine the public's confidence in the ability of the justice system to respond appropriately to fire losses. ∎