

ANALYSIS OF THE FIRE OF 30 SEPTEMBER 1996
AT 4130 HOFFMAN ROAD
Upper Moreland Township
Hatboro, Pennsylvania

Commonwealth of Pennsylvania
vs.
Paul S. Camiolo

Montgomery County
No. 1233 of 1999

by

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This analysis of the house fire on September 30, 1996 at 4130 Hoffman Road, Hatboro, Pennsylvania is intended to serve as a disclosure of my expert opinions concerning this fire. This analysis is based on my review of documents produced by both the Prosecution and the Defense, including photographs of the house where the fire occurred. A list of the documents reviewed is given as Appendix A.

In developing my analysis and opinions, I have relied heavily on my knowledge of Chemistry, Combustion and Fire Science, Mechanical and Chemical Engineering, Fire Cause and Origin Investigations, and Fire Department and Fireground Operations, including my personal experience as a Teacher and Researcher in Combustion and Fire Science and my experience as a Fire Fighter and Fire Department Officer and Instructor. Additional information on my experience and training is provided in my Resume and List of Publications which are given as Appendix B.

My fee for preparation of this report as well as that for testimony by deposition or in court is \$175/hour. Also, Appendix C gives a list of cases in which I have given testimony in court or by deposition in the last five years.

The analysis and opinions expressed in this report are based on my knowledge of facts and information to date. If my opinions (or the bases for them) as expressed below change as a result of additional information which becomes available through depositions or other discovery or further analysis on my part, I will amend or supplement my opinions appropriately.

BACKGROUND

A fire occurred in the house at 4130 Hoffman Road, Hatboro, Pennsylvania at approximately 4:30 a.m. on Monday, September 30, 1996. At the time of the fire, three people were in the house, Edward Camiolo (age 81), his wife, Rose Camiolo (age 57), and their son, Paul Camiolo (age 31). The two-story house, which nominally faced east, was of wood frame construction. The downstairs included a living room and dining room in the front of the house and a family room, kitchen and den/storage room with an adjacent powder room in the back of the house. The upstairs had four bedrooms and a bath. The master bedroom, where Edward and Rose Camiolo slept, was at the head of the stairs.

The fire originated in the family room which was situated in the back, left portion of the downstairs. This room was accessible through a doorway from a hall that ran alongside the stairs from the front door back to the family room and from a doorway from the kitchen.

The fire was reported by Paul Camiolo via 911 at 4:30:35 a.m. The first emergency personnel on the scene was Officer Karen Rosenberger who arrived at the scene at approximately 4:35 a.m. She reported that the large bay window on the left rear of the house had broken out and flames were coming out of it. She found Rose Camiolo on the back porch at the right rear of the house. Officer Rosenberger was also advised by Paul Camiolo that his father, Edward, was still trapped in the house.

Rose Camiolo was described as being conscious and alert but suffering from burns to her upper body and head including singed hair. Paul Camiolo was also observed to have burns on his shoulders and head, although they were less severe than his mother's burns.

The first fire department units arrived at approximately 4:40 a.m. and the fire was declared under control at 5:03 a.m. A fire department search of the house found Edward Camiolo dead in the powder room in the right rear of the first floor near the back door exit where Rose Camiolo was first observed by Officer Rosenberger. Rose Camiolo was treated at the scene for burns and smoke inhalation and transported to the hospital. After initial treatment in the ER, Rose Camiolo was transferred to the Burn Unit of a second Hospital. She ultimately died of complications from the fire on December 18, 1996. Paul Camiolo was also transported (but in a separate ambulance than his mother) to the hospital and was treated for burns and smoke inhalation and was released.

An autopsy performed on Edward Camiolo revealed that he had non-lethal burns to his head and upper torso and had suffered smoke inhalation. He was declared dead by smoke inhalation as a result of carbon monoxide poisoning. His COHb was reported as 45% . An autopsy performed on Rose Camiolo after her death revealed a scar from a healed burn in the palm of her left hand.

A post-fire investigation was conducted by police and fire official including an ATF Agent, Steve Avato, who was a volunteer member of the one of the responding fire departments. The initial investigation was led by Fire Marshall Tom Sullivan of Upper Moreland Township, PA and Pennsylvania State Trooper Barry Whitmoyer. Their investigation determined that the fire originated in the family room in the left rear of the first floor. Examination of the scene

revealed heavy burn damage to most of the furnishings in the family room. Heavy heat and smoke damage was observed throughout the rest of the house with some fire extension into the kitchen and hallway adjacent to the family room.

The family room was approximately 20 feet long by 12 feet wide with a large window and an outside door in the west wall. The room had a brick fire place along the south wall and plywood paneling along the other three walls. A substantial fuel load was present in the room at the time of the fire. The fuel load included a three-cushion couch (with integral recliners at either end) along the east wall, a two-cushion love seat along the west wall, and a lift-type recliner chair near the north wall by the door to the kitchen. In addition, there were several small tables and a television. The family room also had wall-to-wall carpeting over the original hardwood floor (the house was built circa 1971).

Further investigation of the burn damage in the family room showed substantial damage to the couch, the love seat and the lift chair. The greatest damage to the couch was at the north end (toward the kitchen) with damage decreasing toward the south end (toward the fire place). A similar damage pattern was noted on the love seat including greater damage high up on the back of the love seat. The lift chair showed greatest burn damage to the east (toward the couch). The wood paneling and studs behind the couch showed damage beginning behind the north end of the couch with a "V" pattern toward the south (fireplace). In addition, the carpet in the center of the room was heavily damaged including a substantial area where the carpet and padding was gone, revealing the hardwood floor underneath. The hardwood floor showed irregular discoloration in the center of the room where the carpet had been completely burned. Because of the irregular pattern on the hardwood floor, samples were taken of the carpet, padding, newspaper (used between the padding and the hardwood floor to stop squeaks), and floor boards by the Fire Marshall and set to a Pennsylvania State laboratory for analysis.

Paul Camiolo was interviewed by the investigators and gave the following account of the fire. Paul stated that his mother had gone to bed at approximately 8:30 p.m. on Sunday night. His father subsequently went to bed at about 11:30 p.m. Paul fell asleep watching the television, woke up about 2:30 a.m. and went to bed. Paul was awakened at approximately 4:30 a.m. by his father's call for help from downstairs. Paul went downstairs to the family room in response to his father's call and discovered his father in the lift chair and his mother on the couch. Upon entering the family room, Paul observed his mother attempting to pat out a small fire on the

couch with her left hand. Paul immediately went to the kitchen and got a pitcher of water. When he returned to the living room, he attempted to extinguish the fire with the pitcher of water but found that it had little effect on the fire. Paul advised his parent to get out and quickly retreated to the kitchen to call 911. While on the 911 call, Paul observed his parents transiting the kitchen toward the den/storage room as the fire continued to grow. Upon completion of the 911 call, Paul left the house through the front door. After finding some clothes in his car, Paul went to the rear of the house to meet up with his parents. When he arrived at the back of the house neither of his parents were visible so he opened the rear door and found his mother on the floor inside the door. He dragged his mother outside on to the porch but could not reach his father because of the heat and smoke. He then went to the front of the house to await the arrival of emergency personnel. He met Officer Rosenberger and accompanied her around back to his mother while advising Officer Rosenberger that his father was still in the house. Eventually, Paul was taken to the hospital and treated for his smoke inhalation and burn injuries. Paul suggested that the fire started as a result of his mother's mishandling of smoking materials.

Based on the burn damage and Paul Camiolo's statement, the investigation focused on the area near the north end of the couch. A lamp in this area was eliminated as a possible cause of the fire when an examination of the lamp and the adjacent outlet revealed no evidence of damage consistent with initiation of a fire. Careless use of smoking materials could not be eliminated based on the burn damage, the statements of Paul Camiolo, and evidence of other smoking materials throughout the downstairs. Other possible accidental causes of the fire were eliminated as being outside the area of origin.

Initial investigation reports filed by Fire Marshall Sullivan (signed 10-10-96) and by Agent Avato (signed 10/16/96) concluded that the fire was accidental as the result of careless smoking or improper disposal of smoking materials.

On October 24, 1996 a report was received from the State laboratory on the samples submitted by Fire Marshall Sullivan. The report showed that the samples of carpet, padding and newsprint were negative for common ignitable liquids but that the floor boards showed trace amounts of weathered gasoline. After receiving this report, Trooper Whitmoyer closed his fire investigation declaring the cause to be undetermined. However, after receiving this report, Fire Marshall Sullivan change his fire investigation report to conclude that the fire was incendiary through the use of gasoline as an accelerant.

Subsequently, Fire Marshall Sullivan enlisted the aid of another Pennsylvania State Trooper/Fire Marshall, Robert Klein. Trooper Klein together with Fire Marshall Sullivan obtained a search warrant and returned to the house (which had not been secured since the fire) to obtain additional samples for laboratory analysis. These additional samples include carpeting, padding, newsprint and floor boards. In some cases, these samples were all taken from the same area such that the padding, newsprint and floor boards were taken under the area where the carpet sample was taken. In addition, a “control” sample of each of these materials was taken from an area of the room that showed no burn damage. The laboratory analysis consistently showed that the carpet, padding and newsprint contained no gasoline but that the floor boards showed traces of weathered gasoline. Even the “control” samples showed these results, that is, no gasoline on the carpet, padding or newsprint, but weathered gasoline on the floor boards. Several of the carpet samples also showed positive for medium or heavy petroleum distillate.

Based on these findings, Trooper Klein concurred with Fire Marshall Sullivan that the fire was incendiary in nature with gasoline as an accelerant.

ANALYSIS AND OPINIONS

The goal of this analysis is to examine the initiation and development of this fire to determine whether it can be explained by an accidental scenario such as that suggested by Paul Camiolo’s statements and Agent Avato’s analysis or whether it can only be explained as an incendiary fire involving the use of gasoline as an accelerant as proposed by Fire Marshall Sullivan and Trooper Klein.

In order to properly address these two scenarios, a timeline must be developed for the fire under each scenario. The part of the timeline for this fire that is of most importance to this analysis is the time from the start of the fire in the family room until the time when the downstairs becomes untenable. Once the downstairs becomes untenable, movement of the residents would be halted.

Since NFPA 921, The Guide to Fire and Explosion Investigations [1], generally requires that accidental scenarios be eliminated before incendiary scenarios can be considered, the accidental fire on the couch will be examined first. This scenario, as suggested by Paul

Camiolo's statements and developed by Agent Avato, involves a fire which starts on the family room couch as a result of Rose Camiolo mishandling smoking materials.

In order to establish the start of the timeline it is necessary to examine the exact cause of the accidental fire. Two different accidental ignitions are possible: smoldering ignition from a dropped cigarette or flaming ignition from a dropped match. Research reported by various investigators including Gordon Damant shows that if smoldering ignition occurs it generally takes 30 minutes to two hours to transition to flaming [2]. Furthermore, recent improvements in upholstered furniture fabrics make smoldering ignition by a cigarette much less likely. However, even these new fabrics are not resistant to ignition by an open flame. The long time frame for a smoldering ignition as well as the low probability of its occurrence lead to the conclusion that the most likely ignition scenario is a dropped match that causes a flaming ignition of the couch. This is supported by the fact that Paul Camiolo does not report any significant smoke in the hallway as he approaches the family room. Had the couch been smoldering for a significant time, smoke accumulation would have occurred in the hallway. In my opinion, the most likely accidental ignition scenario is a lighted match dropped onto the couch resulting in a flaming ignition of the couch. This establishes the beginning of the accidental fire timeline as a flaming ignition of the couch.

The timeline of this fire was further developed using computer modeling of the couch fire coupled with statements by the witnesses. The computer modeling was performed using two different the computer fire model developed at the National Institute of Standards and Technology (NIST), which is part of the U.S. Department of Commerce.

Zone modeling was employed utilizing the multi-zone computer fire model FAST [3]. FAST is a collection of procedures, which build on the computer model CFAST [4] to provide engineering estimates of fire hazard in compartmented structures. FAST is capable of modeling steady or non-steady burning conditions in multiple compartment configurations. In FAST, the initiating fire is user-specified, but internally controlled by fuel and air supply rates. The model divides each compartment into two zones, an upper zone which contains a hot layer and a lower zone which is, at least initially, relatively cool. The basic equations describe the mass and energy transfer from zone to zone. Mass and energy transfer between the zones is produced by plumes, mixing at vents (connections between compartments), radiation between layers, and heat transfer at the boundary surfaces. The prime equations in FAST are based on the application of

mass and energy conservation principles (control volumes) to homogeneous upper and lower gas regions in multi-compartment systems.

FAST and CFAST are public domain software programs and are readily available free of charge from NIST. A review of the available scientific literature directly related to the development, use, and validation of FAST and CFAST [5-51] demonstrates international acceptance of the model for both research and practical application in fire protection design and post-fire analysis. In addition, the FAST model has been extensively tested and the results have been reported in peer reviewed documents. The three most applicable documents are “Comparing Compartment Fires with Compartment Fire Models” by Nelson and Deal [52], “Verification of a Model of Fire and Smoke Transport” by Peacock, Jones, and Bukowski [53], and “Compartment Fire Experiments: Comparison With Models” by Dembsey, Pagni, and Williamson [54]. These analyses showed good agreement between the model and fire tests for the estimation of temperature and interface height.

The FAST model requires several inputs by the user: 1) the geometry of the room of fire origin and adjacent spaces, 2) ventilation paths between rooms, 3) material properties for the compartment boundaries, and 4) the fire specification (e.g. location and energy release rate as a function of time). The boundary characteristics used in the model were selected to be representative for the specific fire scenario.

Field modeling was also performed by using Industrial Fire Simulator (IFS), a computer fire model that has also been developed at NIST [52]. IFS is a Computational Fluid Dynamics (CFD) model which is based upon Large-Eddy Simulation (LES) analysis. This methodology provides a computationally efficient method of calculating fluid flow and temperatures in a fire environment. This model allows the user to observe the calculated development of the fire through the use of a computer graphical presentation of the computer calculations. Also, unlike FAST which generally requires that the fire be specified by the user, IFS allows the user to specify the properties of the fuel packages in the room and then calculates the growth of the fire.

As with FAST and CFAST, IFS is a public domain software program and available free of charge from NIST. A review of the available scientific literature directly related to the development, use, and validation of IFS [53-98] demonstrates acceptance of the model for both research and practical application. In addition, the theory behind the IFS model has been

described in peer reviewed documents along with validation studies and examples of practical applications.

Because FAST requires much less computer time (results typically take tens of minutes as compared to days or weeks with IFS), it was used as part of the initial analysis of the fire scenarios. Subsequent modeling performed with IFS was compared with the results of the FAST modeling and will also be discussed as part of this analysis.

A heat release curve for a couch fire as measured by NIST [99] combined with heat release data for wood paneling [100] was used as input for the fire in the living room. Using this fire, FAST calculated the time-temperature history of the upper layer in the living room and in adjacent rooms. In addition, FAST calculated the depth of the hot upper gas layer. Using the criteria of 600C upper layer temperature at a depth of at least one meter [101], the time to flashover was determined from the FAST model to be approximately five and one half minutes. This time is consistent with experimental measurements of time to flashover in rooms where a couch [102-105] was initially involved in the fire.

Other important times along the timeline were determined by comparing witness statements with the measured fire growth of the NIST couch fire and by using the time-temperature and upper layer depth histories as calculated by FAST and IFS.

According to the NIST data, at thirty seconds the fire is only 8 kW. Up to this size, the fire would be approximately 10-12 inches in height and would not seem very threatening. It would still be confined to a small portion of the couch and would not extend above the back of the couch.

At sixty seconds into the fire, the fire would have grown to 16 kW. At this size, the fire now would be one to two feet tall. This is approximately the fire condition that Paul Camiolo describes when he first sees his mother trying to pat out the fire.

By ninety seconds, the fire would have grown to approximately 83 kW. At this size, the fire would be extending up toward the ceiling and would be capable of producing second degree burns in less than 30 seconds for anyone within two to three feet of the fire. This is approximately the fire which Paul Camiolo encounters when he returns with the pitcher of water and helps his mother from the couch. At this size, a pitcher of water would have little if any effect on the fire because the melted polyurethane would react much like a grease fire. That is, the water would be more likely to spread the fire than extinguish it.

At two minutes, as Paul is urging his parents to get out, the fire has grown to 230 kW. This fire would begin spreading across the ceiling and would radiate sufficient heat to produce second degree burns on anyone within three to four feet of the fire in less than 10 seconds. At about this time, the upper layer in the living room would have reached 180C in temperature and 0.9 m (3 ft) in depth. According to Cooper [101], these upper layer conditions would shortly result in onset of pain to someone directly exposed to radiation from the upper layer. At this time the flaming melt from the polyurethane is dropping on the carpet around and behind the couch igniting the carpet in these areas. This dripping polyurethane will result in low burn around the north end of the couch and will begin to ignite the paneling behind the couch. This is approximately the point at which Paul and his parents would have left the family room.

At 2-1/2 to 3 minutes after ignition, Paul is making the 911 call to report the fire. At this point the fire has grown to approximately 790 kW. The upper layer temperature in the family room would have exceeded 200C, making the living room untenable. Smoke and hot gases would begin spreading out of the living room into the kitchen and hallway. The presence of this smoke and hot gases would significantly slow down anyone trying to escape the fire [106].

By four minutes after ignition, the fire would have grown to more than 1.5 MW. The CO level would be starting to rise in the smoke leaving the living room as the fire approaches flashover [107]. Near the end of this time, the combination of heat and carbon monoxide would likely be sufficient to cause unconsciousness in the living room. The smoke and hot gases pouring into the adjacent areas would be sufficient to be disorienting, approaching incapacitating. Anyone in the upstairs would likely be unable to safely come down the stairs at this point.

At approximately 5 minutes after the initiation of the fire, the fire would have grown to nearly 2 MW. Smoke and hot gases would be spreading throughout the first floor of the house. The upper layer along the path from the family room to the back door at the den/storage room would be hot enough to cause second degree burns to areas of a person immersed in the upper layer. This is the condition at the time when Paul Camiolo discovers his mother on the floor inside the back door and drags her out to the back porch. At this time Paul Camiolo states that he can hear his father but cannot reach him because of the heat and smoke.

At approximately 5-1/2 minutes after flaming ignition of the couch, the fire has grown to include the carpet around the north end of the couch and the plywood paneling from floor to

ceiling behind the couch. This fire is now large enough to cause flashover of the family room, resulting in ignition of most of the ordinary combustibles throughout the room including the exposed carpet in the center of the room and the top of the love seat. Carbon monoxide levels would quickly rise above 10% in the family room because of the wood paneling in the upper layer [108]. CO levels of 2-3% would be found in the areas adjacent to the family room. These levels of carbon monoxide would result in unconsciousness in less than one minute and death in less than 3 minutes [102]. The rapid heating of the glass in the family room that occurs with flashover will shortly result in complete breakage of the window. The “pop” that Paul Camiolo reports hearing as he heads to the front of the house to meet the emergency personnel is likely the loss of the inside pane of the triple pane window in the family room (such a “pop” has been recently observed in research on fire exposure of multi-pane glass [109]).

At approximately 6 minutes after ignition (approximately 3 minutes after the 911 call), the family room window would have completely failed and fire would be venting out the window. Edward Camiolo would likely be unconscious from carbon monoxide poisoning. This is the time at which Officer Rosenberger arrives at the scene and encounters Paul Camiolo in front of the house. This is the “fully involved” fire condition that Officer Rosenberger reports seeing when she arrives at the back of the house.

At seven to ten minutes after the fire started, fire department units arrived on the scene and began search and rescue and fire suppression activities. However, by this time Edward Camiolo is likely already dead from CO poisoning.

Based on this analysis of the fire development, an assessment can now be made of the accidental fire scenario. In particular, the primary issue to be addressed is whether this fire scenario is consistent with Paul Camiolo’s statements and inconsistent with any of the known facts of the fire.

This analysis of the growth and development of an accidental fire shows that the timeframe of the fire is consistent with a fire which originates with a flaming ignition of the family room couch. The rapid growth and development of the fire leading to flashover in less than six minutes is consistent with the time between Paul Camiolo’s first observance of the fire, the 911 call, and the fire at the time of arrival of Officer Rosenberger. Furthermore, the rapid development of the fire after Paul’s initial attempt to extinguish it, coupled with the age and infirmity of his parents, is consistent with the fact that neither of his parents got out of the house

on their own. This is consistent with medical research which shows that the young, the elderly, the infirm, and those incapacitated by drugs or liquor are most likely to die in residential fires [110].

The artifacts of the fire observed during the post fire investigations are also generally consistent with the accidental fire scenario. All the investigators report burn patterns on the wall and furniture that are most severe near the north end of the couch and least severe at the south end of the family room. These patterns are consistent with the initial finding of Fire Marshall Sullivan and the ultimate finding of Agent Avato that the fire originated on the north end of the couch (toward the kitchen). Even Trooper Klein places the area of origin near the north end of the couch, although he believes the fire started behind the couch because of the low burn on the wall. In fact, this low burn can easily be explained by dripping of flaming polyurethane onto the rug behind the couch. Such behavior has been readily observed in fire tests with polyurethane couches (see for example the Firepower video from NFPA [102]).

The post-fire observation of a large burned-out area of carpet and discolored flooring in the center of the room is consistent with the fact that this accidental fire could generated more than sufficient energy to cause flashover in the family room. Flashover has been shown to cause ignition of carpet in unprotected areas and to cause discoloration of flooring (see for example Kirk's Fire Investigation [111] or the video Why America Burns [112]). Because flashover causes radiant fluxes of 20 kW/m^2 or greater at floor level, it usually results in the appearance of low burning in many areas throughout the flashed-over room. Such burn patterns were readily apparent to all of the investigators of this fire. The fact that flashover occurred is not just evidenced by the appearance of widespread low burning in the family room, but also by the death of Edward Camiolo in the powder room. Research has shown that nearly 80% of fire victims die of carbon monoxide poisoning remote from the room of origin [113]. Additional research has shown that lethal levels of carbon monoxide are not generated outside the room of origin until after flashover [114]. Thus, the fact that Edward Camiolo died remote from the room of fire origin of smoke inhalation (COHb of 45%) is additional evidence that the family room flashed-over. This evidence is also consistent with the accidental fire scenario.

The observation of "crazed" glass at the fire scene is also consistent with the accidental fire scenario. Research has shown that crazing of glass is not specifically related to use of accelerants [111]. In fact, recent research on multi-pane glass has shown that severe "crazing"

occurs under both slow and fast heating of the glass [109]. Thus, the “crazed” glass is consistent with failures frequently observed near flashover.

Finally, artifacts from the autopsy of Rose Camiolo are also consistent with the accidental fire scenario and Paul Camiolo’s statements. Rose Camiolo showed evidence of a healed burn on her left hand that is consistent with Paul Camiolo’s description of his mother initially trying to pat out the flame with her left hand. Furthermore, the burn injuries that extend from Rose Camiolo’s mid thorax to her head indicate that she was exposed to a hot upper layer only from mid chest level up. Such a layer height would not result in hot door knobs or other objects at waist height that could have produced the burn on Rose Camiolo’s hand.

The only artifact from the numerous fire investigations that does not initially appear to be consistent with the accidental fire scenario is the observation of weather gasoline on the floor boards in the living room. It was this finding alone that caused Fire Marshall Sullivan to change his cause of the fire even though it was inconsistent with his origin on the couch. However, this apparent inconsistency quickly fades away after examination of all the laboratory samples. The appearance of weathered gasoline only in the floor boards but not in the carpet, padding or newsprint immediately makes this finding suspect. There is no doubt that weather gasoline was present in the floor boards; this was confirmed by independent samples taken by Investigator Decker and by analysis by Forensic Chemist John Lentini. These independent analyses also confirmed the absence of any gasoline in the carpet, padding or newsprint on top of the floor boards. Furthermore, the “control” samples also showed the presence of weathered gasoline. Gasoline in the control samples indicates that the gasoline was present at the scene prior to the fire. The absence of gasoline in any of the highly absorbent layers above the floor boards also indicates that gasoline was not present on these materials at the time of the fire, as it would be virtually impossible for the gasoline to have soaked through to the floor boards without leaving any residue in the more absorbent layers above the flooring.

The presence of weathered gasoline in the floor boards can be explained by the fact that at the time that this floor was originally installed gasoline was routinely used as an inexpensive solvent for lacquers and other materials used in the treatment of wood. This fact is based on personal knowledge (of the author) and on the investigation of Mr. Decker (who obtained this information from local area flooring installers). Gasoline used in this fashion can be sealed into the wood by a finish coating. The association of the weathered gasoline with the original floor

installation is also supported by the finding of traces of lead in the flooring samples by Forensic Chemist John Lentini. Although leaded gasoline was readily available in the early seventies, its phase-out began with the advent of catalytic converters in the mid-seventies (it is a poison for the catalyst) By the mid-eighties, the EPA had all but banned use of leaded gasoline because of its impact on lead levels in the blood of urban children. By the time of this fire in 1996, leaded gasoline had not been readily available for many years [115].

Based on this information and analysis, the presence of weathered gasoline in the floor boards but not in the carpet, padding or newsprint is consistent with the accidental scenario described above. It should be noted that the presence of mid/heavy petroleum distillate in several of the later carpet samples can be readily explained by the previous use of a kerosene heater and by the use of insecticides which contain these petroleum distillates as solvents. Since these petroleum distillates are not very volatile, they can remain in carpet for many years. Thus, even these findings are not inconsistent with the accidental fire scenario.

Based on the detailed modeling and analysis presented above, I can find no evidence that is inconsistent with the accidental scenario described by Agent Avato in his fire investigation report. Furthermore, there is nothing in my analysis of this accidental fire scenario that contradicts Paul Camiolo's statements regarding the fire. Therefore, it is my opinion, that this fire was an accidental fire which originated on the family room couch as the result of Rose Camiolo mishandling smoking materials.

Since proper scientific and investigative methodology (as described in NFPA921, for example) precludes the finding of an incendiary fire when any reasonable accidental cause can not be eliminated, it would normally be unnecessary and inappropriate to further analyze the arson scenario suggested by Fire Marshall Sullivan and Trooper Klein. However, since this incendiary scenario has been used as the basis for a criminal complaint, I feel compelled to analyze it.

Modeling and analysis was also used to develop a timeline for an incendiary fire scenario resulting from the use of gasoline over a wide area of the family room. This scenario is based on the opinion of Trooper Klein and Fire Marshall Sullivan that the large area of burn in the middle of the family room and the discoloration on the flooring constituted a "flammable liquid pour pattern."

The appearance of such pour patterns is typically thought to result from the rapid and unusually hot burning of a flammable liquid on the carpet or flooring. However, research has shown that such patterns are not the result of flammable liquid pours, but rather the result of flashover [111]. These results are not surprising given the fact that the flame temperature of gasoline is approximately the same as the flame temperature of wood or other ordinary combustibles [101]. Furthermore, it has long been known that the latent heat of vaporization of liquids serves to cool the surface that the liquid is on. This effect (similar to the cooling effect of rubbing alcohol on the skin) actually results in the surface under the flammable liquid being cooler than the surrounding area, not hotter.

Despite this apparent inconsistency, the arson scenario was modeled by assuming that gasoline was poured in the area described as the “pour pattern” by Trooper Klein in his testimony at the preliminary hearing. A pour of one gallon of gasoline was assumed since this is the minimum that would reasonably cover the indicated area.

The modeling shows a fire that nearly instantaneously spreads across the pour area (flame spread rates on flammable liquid pools are on the order of several meters per second [101]). The entire gallon of gasoline is consumed in approximately 10 seconds. This rapid burning of the gasoline results in flashover level temperatures at the ceiling within six seconds. The rapid spread of the fire also serves to ignite both the love seat and the couch low down, along their entire fronts nearly simultaneously. After the initial “flash” that results from the gasoline burn-off, the window is broken out (or even possibly blows out from the overpressure) and the couch and love seat readily burn. This combination would lead to rapid extension of the fire out the window and up the side of the house.

Within thirty seconds of the ignition (a time equal to the time that Paul Camiolo spent on the 911 call), hot gases would have spread down the hallway and up the stairs. In fact, the IFS model indicates that the spread of these hot gases is so rapid that the person igniting the gasoline might not be able to escape the house.

Within one minute, the smoke and hot gases spreading up the stairs to the second floor make the stairway untenable, trapping anyone on the second floor.

Three minutes after ignition, the family room would have reached a sustained flashover as a result of the rapid involvement of the couch and love seat. Within tens of seconds after this point toxic levels of CO would spread rapidly through the entire house.

Based on this timeline for the incendiary fire , it is clear that there are several aspects of this scenario that are inconsistent with the known facts of this fire.

First, under this scenario, if Edward and Rose Camiolo were in the family room at the start of the fire, they would have been nearly instantaneously burned (including ignition of their clothing) and, therefore, would have been found dead in the family room. Alternatively, if Mr. and Mrs. Camiolo were upstairs in their bedroom at the start of this fire, by the time that they could have been aware of the fire, they would not have been able to get down the stairs. Thus, they would have been found dead upstairs or on or at the bottom of the stairs. Either of these alternatives is inconsistent with where Mr. And Mrs. Camiolo were actually found by emergency personnel.

Since this fire scenario leads to nearly instantaneous ignition across the front of the love seat and couch, a pattern of uniform burning of the couch and love seat would have been observed after the fire. This is inconsistent with the patterns described by all of the investigators including Trooper Klein and Fire Marshall Sullivan, which show a gradient in burn damage from north to south.

Finally, the timeline for this scenario results in much greater fire damage and substantially more extensive fire spread prior to the arrival of Officer Rosenberger and, subsequently, the fire department. The fact that most of the flame damage was confined to the room of origin is consistent with flashover preceding the arrival of the fire department by no more than several minutes. The substantial fire damage in other areas of the house predicted for the incendiary scenario is inconsistent with the actual level of damage described by all of the investigators after the fire.

One other aspect of this fire requires comment. It has been suggested that the fact that the family dog was found dead in the upstairs bedroom somehow supports a finding of incendiary as the cause of this fire. I do not understand the basis of this claim. I have searched the scientific literature and had discussions with Veterinarians (including a Veterinary Pathologist) to determine if there is any scientific basis for inferring anything about the cause and origin of this fire based on where the dog was found. I have been unable to find any scientific evidence to support any inference concerning this fire based on where the dog was found after the fire. If anything, the literature that was found suggests there is no consistent behavior expected of dogs in such a situation.

Based on this further analysis and modeling, I concluded that there are numerous inconsistencies with an incendiary scenario as described by Fire Marshall Sullivan and Trooper Klein. In my opinion, these inconsistencies allow elimination of this scenario as a possible cause of the fire on September 30, 1996.

SUMMARY AND CONCLUSIONS

Detailed analysis and modeling of the fire at 4130 Hoffman Street shows that an accidental couch fire caused by improperly handled smoking materials is consistent with all known facts of the incident. Furthermore, this accidental scenario is entirely consistent with the statements made by Paul Camiolo concerning the fire. Additional analysis of an incendiary fire scenario revealed numerous inconsistencies between that scenario and undisputed facts of the fire.

In my opinion, the cause of the fire in the Camiolo residence was accidental as a result of ignition of the family room couch by mishandled smoking materials. This conclusion supports the findings of Agent Avato as reported in his ATF fire investigation report of October 1996. I also concur with Agent Avato that a detailed analysis of an incendiary fire shows that such a fire can be ruled out as the cause of the fire in the Camiolo residence.

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114. Gottuk, D.T., Roby, R.J. and Beyler, C.L., "A Study of Carbon Monoxide and Smoke Yields from Compartment Fires," *Twenty-Fourth Symposium (International) on Combustion*, The Combustion Institute, Pittsburgh, PA., 1993.
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Appendix A

List of Documents Reviewed

List of Documents Reviewed for Commonwealth of Pennsylvania v. Paul S. Camiolo

1. Letter from George L Wert to Mark Miller, September 5, 1997, Re: Your File: Camiolo Fire TIS File Number:97-081
2. Discovery Outline, Commonwealth vs. Paul S. Camiolo Montgomery County #1233 of 1999
3. Information on Leaded Gasoline phase-out and ban
4. Expert Report of Gordon H. Damant
5. Township of Upper Moreland Fire Investigation Report, Control # FI-9600014
6. Deposition of Steven J. Avato. Camiolo v. State Farm Fire and Casualty. United States District Court for the Eastern District of Pennsylvania. Case No. 97-8057
7. Transcripts of 911 call # 96-0416
8. Color photocopies of Camiolo residence.
9. September 30, 1999 videotape and November 2, 1996 videotape.
10. Montgomery County Detectives Supplemental Report, Report No, 96-0416
11. Office of the Medical Examiner, City of Philadelphia, Report of Autopsy of Rose Camiolo. Case No, 96-5494, December 18, 1996
12. Report of Autopsy of Camiolo, Edward, #BCC96-388, September 30,1996
13. Emergency/ Trauma Records From Abington Memorial Hospital , Patient: Rosalie A. Camiolo, September 30, 1996
14. Facsimile Transmission from Douglas J. Carpenter to Thomas Cometa, September 13, 1999
15. Facsimile Transmission from Richard J. Roby to Thomas S. Cometa, October 15, 1999
16. Deposition of Paul S. Camiolo. Camiolo v. State Farm Insurance Co. United States District Court for the Eastern District of Pennsylvania. Case No. 97-8057
17. Deposition of Ronald F. Decker. Camiolo and State Farm Insurance Co. United States District Court for the Eastern District of Pennsylvania. Case No. 97-8057
18. Deposition of Lisa McCarty. Camiolo v. State Farm Fire and Casualty. United States District Court for the Eastern District of Pennsylvania. Case No. 97-8057

19. Examination Under Oath of Paul S. Camiolo, In Re: Edward Camiolo and Rosalie Camiolo and State Farm Insurance Companies, January 15, 1997
20. Oral Deposition of Walter R. Kerr. Paul Camiolo vs. State Farm Fire and Casualty Co. United States District Court for the Eastern District of Pennsylvania. Case No. 97-8057
21. Preliminary Hearing. Commonwealth of Pennsylvania vs. Paul S. Camiolo, February 11, 1999
22. Preliminary Hearing. Commonwealth of Pennsylvania vs. Paul S. Camiolo, February 15, 1999
23. Testimony of Steven Avato. August 13, 1998 In Re: 1997-1998 Investigating: Misc. No. 361 Grand Jury April 1997. Court of Common Pleas in and for The County of Montgomery, Pennsylvania Criminal Division
24. Testimony of Steven Avato. September 10, 1998 In Re: 1997-1998 Investigating: Miscellaneous. No. 361 Grand Jury April 1997 Investigation No. 22. Court of Common Pleas in and for The County of Montgomery, Pennsylvania Criminal Division
25. Testimony of Steven Avato. September 17, 1998 In Re: County Investigating Grand Jury 1997/1998: Misc. No. 361, April 1997 Investigation 22. Court of Common Pleas in and for The County of Montgomery, Pennsylvania Criminal Division
26. Exhibit 6, Laboratory Report, Bethlehem Regional Laboratory, Lab Report: B96-4015-T, October 24, 1996, Incident No.:96-11018
27. Exhibit 5, Laboratory Report, Bethlehem Regional Laboratory, Lab Report: B96-4015-T, December 12, 1996, Incident No.:96-11018
28. Laboratory Report, Bethlehem Regional Laboratory, Lab Report: B96-4015-T, July 29, 1997, Incident No.:96-11018
29. Exhibit 7, Time/Temp calculations, July 31, 1998
30. Photographs of investigation, including interior and exterior house photographs and autopsy photographs
31. Investigation Interview Record of Paul Camiolo, Upper Moreland Township Police Dept. Case No. 96-11018, September 30, 1996
32. Pennsylvania State Police Fire Investigation Report/Worksheet, Incident No. K3-901698, September 30, 1996
33. Township of Upper Moreland Fire Investigation Report, Office of the Fire Marshal, Control # FI-9600014, September 30, 1996

34. Fire Investigation Report of Robert H. Jones Associates, Inc. File # 2342K, Claim #: 38D495552, March 28, 1997
35. Fire Investigation Report of Decker-Neff Investigations, Inc. DNI File:7-00-040, August 17, 1997
36. Pennsylvania EMS Report, Second Alarmers Amb \$ Rescue, Transport Date September 30, 1996, Service Incident # 46646
37. Department of the Treasury- Bureau of Alcohol, Tobacco and Firearms Report of Investigation, Investigation No. 742103-97-0005
38. Deposition of Steven J. Avato
39. Letter from Thomas S. Cometa to John J. Lentini, June 10, 1999, Re: Commonwealth Vs. Paul Camiolo
40. Letter from Thomas S. Cometa to Ron Decker , June 10, 1999, Re: Commonwealth of Pennsylvania vs. Paul S. Camiolo, Mont. Co. No. 1233 of 1999 Expert Report of Gordon H. Damant
41. Schematic of 4130 Hoffman Road
42. Report from National Medical Services, Inc., Ref: Camiolo, Paul Case No. 7-00-040

Appendix B

Resume and List of Publications

RICHARD J. ROBY, P.E., Ph.D., Technical Director

Education:

Ph.D., Mechanical Engineering, Stanford University, Palo Alto, CA, Jan. 1988.

M.S., Mechanical Engineering, Cornell University, Ithaca, NY, May 1980.

B.S., Chemical Engineering, Cornell University, Ithaca, NY, May 1977.

A.B., Chemistry, Cornell University, Ithaca, NY, May 1977.

Professional Experience:

President and Technical Director, Combustion Science & Engineering, Columbia, MD, 1998 to present. Responsible for day-to day operations of the company and for overseeing technical content of all research and development projects. Project manager for a variety of experimental and analytical combustion and fire science research and development programs.

Adjunct Professor, Mechanical Engineering Department, Virginia Polytechnic Institute & State University, Blacksburg, VA, 1992 - present. Advisor for one Master's student and Co-Advisor for two Doctoral and one Master's student. Principal Investigator on an experimental study of NO to NO₂ conversion at super-atmospheric pressures. Co-Principal Investigator on an experimental research project on soot formation in mixed-mode combustion. Co-Principal investigator on an on-going experimental research project on CO generation and transport in compartment fires. Continuing member of several graduate thesis committees.

Director of Combustion Research, Hughes Associates, Inc., Baltimore, MD, 1992 to 1998. Responsible for determining scope and content of combustion research and development. Project manager for a variety of combustion and fire science research and development programs. Combustion-related projects included NO_x control with high amounts of water addition; catalytic reformation of natural gas for ultra-lean combustion; reduction of soot formation in methane arcjet thrusters; advanced fire detection using multiple detection techniques; determination of compression ratio effects on aldehyde-NO_x emissions trade-offs in spark ignition engines; and, development of optical combustion diagnostics for gas turbine engines. Managed a number of fire-related R&D programs and provided litigation support and expert witness testimony. Fire-related projects included small and large-scale fire testing, fire reconstruction, studies into the formation and spread of CO, multi-sensor fire detection, code and code equivalency analyses, fire hazard analysis and fire modeling.

Associate Professor, Mechanical Engineering Department, Virginia Polytechnic Institute & State University, Blacksburg, VA, 1992 (Assistant Professor, 1986 - 1992). Responsible for teaching both undergraduate and graduate courses in the thermal-fluid sciences including Combustion, Thermodynamics, Internal Combustion Engines, Experimental Methods in Thermal-Fluid Sciences and Heat Transfer. Advised thesis research for MS and PhD students. Research in combustion generated pollutant formation and control, especially NO_x and soot; combustion diagnostics; compartment fire dynamics, particularly toxic species generation. Applications included spark ignition and diesel engines and aero and stationary gas turbines.

Research Assistant, Mechanical Engineering Department, Stanford University, Palo Alto, CA, 1983-1986.

Research Engineer, Fuels and Lubricants Department, Ford Motor Company, Scientific Research Labs, Dearborn, Michigan, 1979 - 1983.

Research Assistant, Mechanical and Aerospace Engineering Department, Cornell University, Ithaca, NY, 1977-1979.

Membership in Professional Organizations and Honor Societies:

Member, The Combustion Institute
Member, The Society of Automotive Engineers
Member, International Association for Fire Safety Science
Member, National Fire Protection Association
Member, Society of Fire Protection Engineers
Member, The American Institute for Aeronautics and Astronautics
Member, The American Society of Mechanical Engineers
Member, The Planetary Society
Member, Sigma Xi, The Scientific Research Society

Professional Registration:

Registered Professional Engineer, Mechanical Engineering, License Number M 024534 (California 1986).

Fire Department Experience:

Member, Belleville Volunteer Fire Department, Belleville, MI, 1980-1981

Member, Ithaca Fire Department, Ithaca, NY, 1973-1979
Lieutenant, Neriton Fire Company No. 9, 1976-1979
Department Instructor, 1976-1979

Patents:

Roby, R. J., Gottuk, D. T., and Beyler, C. L., "Multi-Signature Fire Detector," U.S. Patent No. 5,691,703, Issued November 25, 1997.

Selected Publications:

Lattimer, B.Y., U. Vandsburger, and R.J. Roby, "Carbon Monoxide Levels in Structure Fires: Effects of Wood in the Upper Layer of a Post-Flashover Compartment Fire," *Fire Technology*, Vol. 34, No. 4, 1998.

Roby, R.J., J.E. Reaney, and E.L. Johnsson, "Detection of Temperature and Equivalence Ratio in Turbulent Premixed Flames using Chemiluminescence," presented at ASME International Joint Power Generation Conference, Baltimore, MD, August 23-26, 1998.

- Hamer, A.J., Roby, R.J., and Klassen, M.S., "Comparison of Reduced Chemical Kinetics Mechanisms for Pollutant Emissions Predictions in Gas Turbines," presented at the ASME International Joint Power Generation Conference, Baltimore, MD, August 23-26, 1998.
- Nicol, D. G., Malte, P. C., Hamer, A. J., Roby, R. J. and Steele, R. C., "Development of a Five-Step Methane Oxidation-NO Formation Mechanism for Lean-Premixed Gas Turbine Combustion," Paper No. 98-GT-185, ASME/IGTI Turbo Expo, Stockholm, Sweden, June 1998.
- Hamer, A.J. and Roby, R.J., "CFD Modeling of a Gas Turbine Combustor Using Reduced Chemical Kinetic Mechanisms", Paper No. 97-3242, 33rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Seattle, WA, July, 1997.
- Lattimer, B.Y., U. Vandsburger, and R.J. Roby, "The Transport of Carbon Monoxide from a Burning Compartment Located on the Side of a Hallway," *26th Symposium (International) on Combustion*, The Combustion Institute, Pittsburgh, PA, 1997.
- Hunderup, J.W., and R.J. Roby, "An Experimental Investigation of the Conversion of NO to NO₂ at High Pressure," Paper No. 95-GT-306, presented at the IGTI meeting of ASME, Houston, TX, June 5-8, 1995 (accepted for publication in *ASME Journal of Engineering for Gas Turbines and Power*).
- Blevins, L.G., and R.J. Roby, "An Experimental Study of NO_x Reduction in Laminar Diffusion Flames by Addition of High Levels of Steam," Paper No. 95-GT-327, presented at the IGTI meeting of ASME, Houston, TX, June 5-8, 1995.
- Gottuk, D.T., and Roby, R.J., "Effect of Combustion Conditions on Species Production," Section 2/Chapter 7, *The SFPE Handbook of Fire Protection Engineering*, P.J. DiNenno (ed.), Second Edition, National Fire Protection Association, Quincy, MA, June 1995.
- Roby, R.J., A.J. Hamer, E.L. Johnsson, S.A. Tilstra, and T.J. Burt, "Improved Method for Flame Detection in Combustion Turbines," *ASME Journal of Engineering for Gas Turbines and Power*, **117** (2), 1995.
- Gottuk, D.T., R.J. Roby, and C.L. Beyler, "The Role of Temperature on Carbon Monoxide Production in Compartment Fires," *Fire Safety Journal*, **24** (4), 1995.
- Lattimer, B.Y., D.S. Ewens, U. Vandsburger, and R.J. Roby, "Transport and Oxidation of Compartment Fire Exhaust Gases in an Adjacent Corridor," *Journal of Fire Protection Engineering*, **6** (4), 1994, pp. 163-181.
- Becker, W.J., R.J. Roby, W.F. O'Brien and G.K. Bensing, "Dynamic Turbine Blade Temperature Measurement," *Journal of Propulsion and Power*, **10** (1), 1994, also AIAA Paper #89-2689, presented at the AIAA/SAE/ASME/ASEE 25th Joint Propulsion Conference, Monterey, CA, July 1989.

- Foss, D.T., R.J. Roby, and W.F. O'Brien, "Development of a Dual-frequency Microwave Burn-rate Measurement for Solid Rocket Propellant," *Journal of Propulsion and Power*, **9** (4), 1993, pp. 497-498.
- Ewens, D.S., U. Vandsburger, and R.J. Roby, "Oxidation of Exhaust Gases from a Burning Compartment in a Remote Location," Paper No. 69, presented at the Eastern States Section Meeting of The Combustion Institute, Princeton, NJ, October 1993.
- Aftel, R., U. Vandsburger, and R.J. Roby, "Soot Formation in Dual-mode Counterflow Flames," Paper No. 61, presented at the Eastern States Section Meeting of The Combustion Institute, Princeton, NJ, October 1993.
- Blevins, L.G., and R.J. Roby, "Effects of High Levels of Steam Addition on NO_x Reduction in Laminar Opposed Flow Diffusion Flames," WSS/CI Paper No. 92-16, presented at the Western States Section Meeting of The Combustion Institute, Corvallis, OR, March 1992.
- Gottuk, D.T., Roby, R.J. and Beyler, C.L., "A Study of Carbon Monoxide and Smoke Yields from Compartment Fires," *Twenty-Fourth Symposium (International) on Combustion*, The Combustion Institute, Pittsburgh, PA., 1993.
- Gottuk, D.T., R.J. Roby, M.J. Peatross, and C.L. Beyler, "Carbon Monoxide Production in Compartment Fires," *J. Fire Protection Engineering*, **4** (4), 1992, pp. 133-150.
- Gottuk, D.T., Roby, R.J. and C.L. Beyler, "The Effect of External Burning on Carbon Monoxide and Smoke Yields from Hexane-Fueled Compartment Fires," paper no. 87, Presented at the Eastern States Section Meeting of the Combustion Institute, Ithaca, New York, 1991.
- Skelly, M.J., R.J. Roby, and C.L. Beyler, "Window Breakage in Compartment Fires," *J. Fire Protection Engineering*, **3** (1), 1991, pp. 25-34.
- Gottuk, D.T., Roby, R.J. and C.L. Beyler, "Carbon Monoxide Yields from Hexane-Fueled Compartment Fires," paper no. 65, presented at the Eastern States Section Meeting of the Combustion Institute, Orlando, FL, December 1990.
- Roby, R.J., "Review of Principles of Fire Protection Chemistry," *Fire Technology*, May 1990.
- Tobin, K.W., M.R. Cates, D.L. Beshears, J.D. Muhs, G.J. Capps, D.B. Smith, W.D. Turley, W. Lewis, B.W. Noel, H.M. Borella, W.F. O'Brien, R.J. Roby and T.T. Anderson, "Engine Testing of Thermographic Phosphors," Oak Ridge National Laboratory Report #ORNL/ATD-31, 1990.
- Wirth, D.A. and R.J. Roby, "Soot Formation in Staged Combustion," paper no. 61, presented at the Eastern States Section Meeting of the Combustion Institute, Albany, NY, October 1989.

- Foss, D.T., R.J. Roby and W.F. O'Brien, "A Dual-Frequency Microwave Burn-Rate Measurement System for Solid Rocket Motors," AIAA Paper #89-2530, presented at the AIAA/SAE/ASME/ASEE 25th Joint Propulsion Conference, Monterey, CA, July 1989.
- Stouffer, S.D., R.J. Roby, and W.F. O'Brien, "Improved Plasma Torch for Ignition and Flame Holding in Supersonic Combustion," AIAA Paper #89-2945, presented at the AIAA/SAE/ASME/ASEE 25th Joint Propulsion Conference, Monterey, CA, July 1989.
- Roby, R.J. and C.T. Bowman, "Formation of N₂O in Laminar, Premixed, Fuel-Rich Flames," *Combustion and Flame*, **70**, 119-123, 1987.
- Roby, R.J. and C.T. Bowman, "Effects of Hydrocarbons on NO Removal in Rich, Premixed Hydrogen-Oxygen Flames," WSS/CI Paper 86-42, 24p., Presented at the Joint Meeting of the Western States and Canadian Sections of the Combustion Institute, Banff, Alberta, Canada, April 1986.
- Freeman, L.E., G.K. Chui, D. Crowl and R.J. Roby, "A Comparative Study of the Effects of Fuel Properties of Non-Petroleum Fuels on Diesel Engine Combustion and Emissions," *Transactions SAE*, Vol 93, Paper #841334, pp 35-50 of SP-587, also presented at the Fall Meeting of the Fuels and Lubricants Section of the Society of Automotive Engineers, Baltimore, Maryland, October 1984.
- Otto, C. and R.J. Roby, "Nitric Oxide Formation from Fuel Nitrogen Studied with a Pulse-Flame Combustor," *J.A.P.C.A.*, Vol. 34, No. 1, pp 38-41, January 1984.
- Freeman, L.E., R.J. Roby and G.K. Chui, "Performance and Emissions of Non-Petroleum Fuels in A Direct-Injection, Stratified-Charge, SI Engine," published in *Fuel Alternatives for the 80's*, SAE, Warrendale, PA (1982), SAE Paper #821198, pp 89-100 of SP-527, also presented at the Fall Meeting of the Fuels and Lubricants Section of the Society of Automotive Engineers, Toronto, Canada, November 1982.
- Freeman, L.E. and R.J. Roby, "Synthetic Fuels from Coal for Automotive Use," Proceedings of the 54th Annual National Technical Association Convention, Baltimore, Maryland, August 1982.
- Roby, R.J., L.E. Freeman, J.A. Harrington, G.K. Chui and W.A. Tallent, "Operation of a Direct-Injection, Stratified-Charge, SI Engine on Alcohols," *Proceedings of the Fifth International Symposium on Alcohol Fuels Technology*, Auckland, New Zealand, May 1982.
- Roby, R.J., G.K. Chui, L.E. Freeman, J.A. Harrington and W.A. Tallent, "Evaluation of Coal Liquids in a Single Cylinder PROCOCO Engine," SAE Paper #811223, also presented at the Fall Meeting of the Fuels and Lubricants Section of the Society of Automotive Engineers, Tulsa, Oklahoma, October 1981.

Roby, R.J. and J.A. Harrington, "Organic Nitrites in Aged Exhaust from Alcohol-Fueled Vehicles", *J.A.P.C.A.*, Vol. 31, No. 9, pp 995-996, September, 1981.

Harrington, J.A., R.J. Roby and J.A. Cavolowsky, "Fuel Vaporization for Fast Cold Starting of Ethanol-Fueled Vehicles", *Proceedings of the Fourth International Symposium on Alcohol Fuels Technology*, Sao Paulo, Brazil, October, 1980.

DeStefano, A.J., R.J. Roby and R.F. Porter, "A Thermodynamic Study of H-D Exchange in the Hydrogen-Difluoroborane System," *Thermochimica Acta*, 16, 236-239, 1976.

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Appendix C

Trial and Deposition Testimony Experience

Trial Testimony:

Nationwide Mutual Fire Insurance Co. v. Black and Decker
Superior Court, State of Connecticut, Hartford District
July 9, 1998.

State of Maryland v. Theodore S. Smith
Circuit Court for Somerset County, Maryland
January 23, 1996.

IFC Nonwovens, Inc. et al. v. Premier Corporation, et al.,
U. S. District Court, Western District of Tennessee, No. 90-1025
August 3, 1995.

State of Maryland v. Theodore S. Smith
Circuit Court for Somerset County, Maryland
April 11-14, 1995.

David W. Maxwell v. W. David Turner d/b/a Wythe Sheet Metal Co.
Circuit Court for Wythe County, Virginia
August 1993.

Deposition Testimony:

Warf v. Simon-Telelect, Inc. and Eusco, Inc.
Circuit Court of Davidson County, State of Tennessee at Nashville
September 17, 1998.

Nationwide Mutual Fire Insurance Co. v. Black and Decker
Superior Court, State of Connecticut, Hartford District
May 27, 1998.

Moore-Dandridge et al. v. Washington Gas Light Co. et al.
Superior Court of the District of Columbia
October 29, 1997.

Baldwin and Baldwin v. State Farm
United States District Court
Western District of Virginia
September 9, 1997.

Asselin, et al. v. Amigo Mobility International et al.
State of Connecticut: Superior Court
Judicial District of New Haven at Meriden
July 18, 1997.

Bethlehem Steel Corp., v. Bridgewater Protective Coatings, Inc. et al.
United States District Court, Northern District of Maryland
January 30, 1997.

Daniel J. Hartnett, et ux. v. Globe Firefighter Suits, Inc., et al.
United States District Court, Southern District of Maryland
November 22, 1996.

Jeremy Ward et al. v. Clement Weber et al.
Vanderburgh Superior Court, State of Indiana
October 1996

Spencer v. Deauville Assoc. Ltd. Partnership, et al.
Superior Court for the District of Columbia
August 31, 1995

William Lethco et al. v. W. David Turner d/b/a Wythe Sheet Metal Co.
Circuit Court for Wythe County, Virginia
May 1995.

William W. Monsson at al. v. Frank J. Whitecavage, et al.
Circuit Court for Cecil County, Maryland, Civil Action No. 92190L
November 22, 1995.

IFC Nonwovens, Inc. et al. v. Premier Corporation, et al.
U. S. District Court, Western District of Tennessee, No. 90-1025
July 12-13, 1994 and October 4-5, 1994.

Cooper, v. National Health Care Foundation for the Deaf, Inc.
District of Columbia: Civil Action No. 93-CA10452
July 28, 1994.

*Burns Construction Company v. E. D. Etnyre & Co., et al.,
Philip Clark v. E. D. Etnyre & Co., et al.*
Virginia: In The Circuit Court of The City of Richmond
December 13, 1993.

*American National Fire Insurance Co. v. Hitchcock Company, Inc. v. Becker & Son
Sheet Metal, Inc., f/k/a Becker Sheet Metal, Inc. and Lennox Furnaces, Inc.*
United States District Court, District of Connecticut
December 9, 1993.

David W. Maxwell v. W. David Turner d/b/a Wythe Sheet Metal Co.
Virginia: In the Circuit Court for Wythe County,
February 19, 1993.