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FIRE INVESTIGATION
An Analysis of the Waldbaum Fire, Brooklyn, NY
August 3, 1978

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Dedication: Prof. Kunio Kawagoe provided inspiration as an administrator, researcher, and teacher in the field of fire safety. I have benefitted greatly from his scientific contributions, and have memories of many friendly moments. I think he sought to have fire science confront the real world, and therefore I submit this paper to the Kawagoe Memoriam in his honor.

ABSTRACT

An analysis of the Waldbaum supermarket fire, Brooklyn, NY, August 3, 1978 is presented. It is argued that the fire went from flaming to smoldering and back to flaming over a period of several hours. This mostly hidden fire broke into the loft and led to the collapse of the roof. As a result, 12 firefighters fell into the flames and six perished. The fire was never satisfactorily explained, and a retrial of a man convicted of arson prompted this analysis.

Introduction

Fire investigation has not generally used the tools of fire science to explain the scenario of the fire. It has relied on chemical evidence to identify ignition causes, but has not necessarily relied on the characteristics of the fire to explain its cause. The application of fire science to investigation has a dual benefit since it not only can assist the fire investigator, but it also reveals fire behavior that should be recognized by fire scientists. We shall consider one such application.

On August 3, 1978 a fire occurred at the Waldbaum supermarket in Brooklyn, NY. A sketch of the store is shown in Figure 1. At the time of the fire, an extension was under construction as indicated. The store was a typical supermarket with a mezzanine along a portion of the north wall. The loft was completely of wood construction comprising the floor, roof,

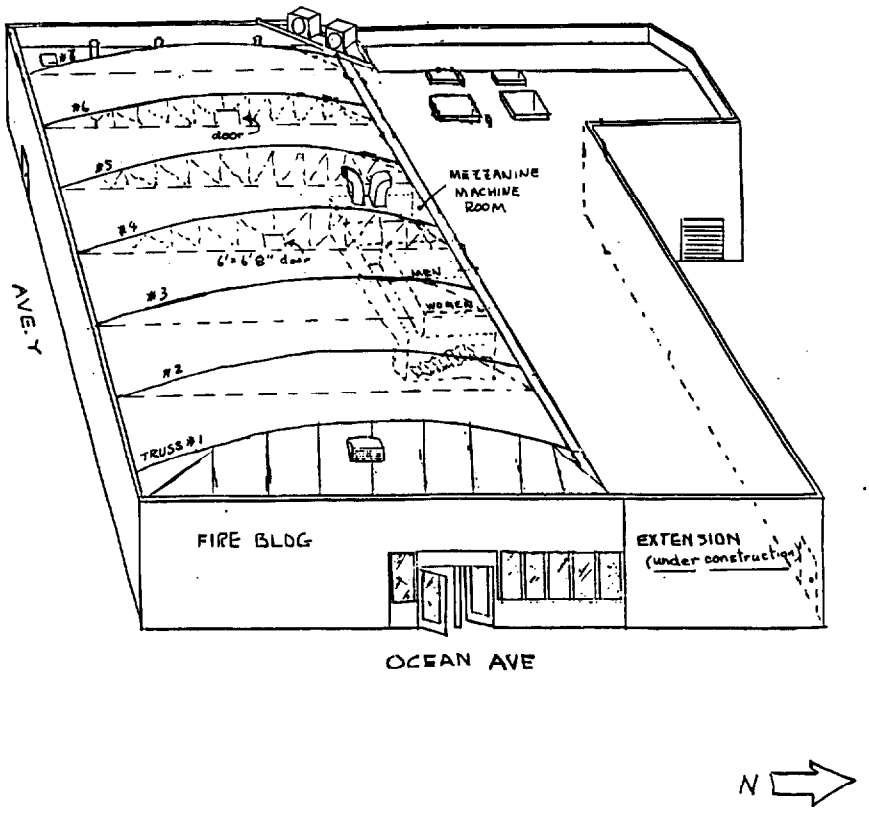

Figure 1. Overview of store with the extension under construction.

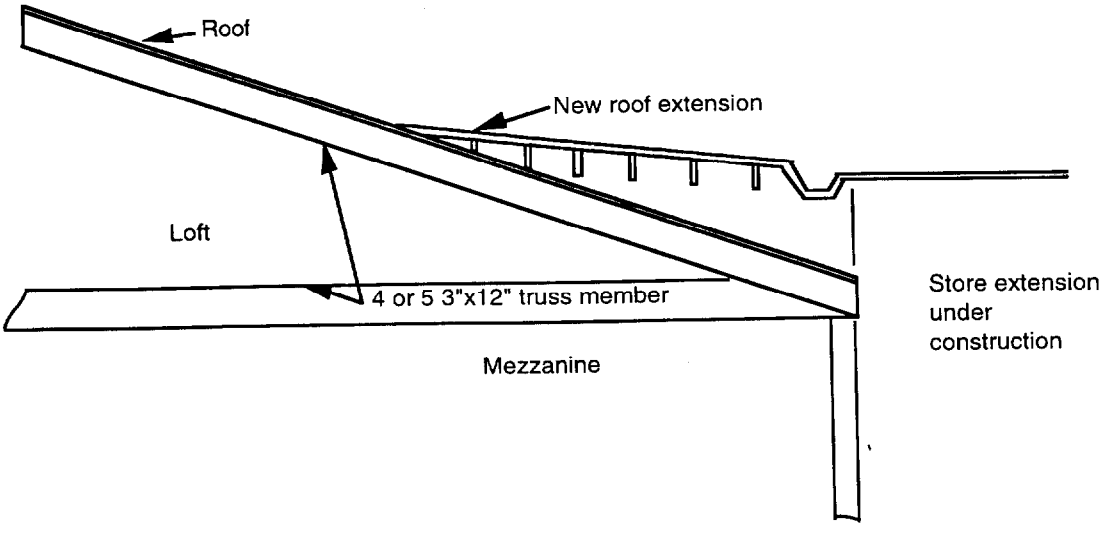

Figure 2. Splayed roof extension.

and structural support trusses. The trusses were made of 3 x 12 in. Members were interlaced together in bundles of 4 or 5. Trusses 2, 4, and 6 were covered on one side with plaster to form fire walls in the loft. However, for passage, these trusses had doorway openings. The roof had been modified with an added rain roof at the peak. This formed a double layer roof at the peak. Also the new construction called for a splayed roof section to meet the new roof of the extension. This formed another double roof triangular section along the north wall as shown in Figure 2. Due to the construction and the addition of new columns along the wall to the extension, construction voids existed along this wall.

The store opened for business at 8 a. m. and the construction work had been underway since 7 a. m. Flames were first seen at 8:30 a. m. along the interface between the ceiling and extension wall of the mezzanine Men's room and the machine room. The fire eventually spread into the loft between truss sections 4 and 6, and collapsed truss 5 at approximately 9:15 a. m. This caused 6 firefighters to fall into the flames to their death.

A man was tried and convicted in 1978 of setting this fire. His confession stated that he and two others set the fire near dawn (approximately 6 a. m.) by making holes in the roof and using newspaper and lighter fluid to initiate the fire below. This confession was later questioned and discounted in a retrial that was held in 1994. The fire scenario was never explained. The original fire investigators could not agree on a cause, and later suggested that it may have been of electrical origin. However, there was no electrical power in the ceiling area where flames were first seen, and a man in the loft at the onset of the flames saw no evidence of fire. The prosecutors sought advice on how to explain an alleged fire start at 6 a. m., but not seen until 8:30 a. m.

I was asked to assist William J. Petretis, Special Agent, of the Bureau of Alcohol, Tobacco and Firearms in the investigation of this fire 16 years after it occurred. Agent Petretis discovered the splayed roof extension shown in Figure 2, and reasoned the fire had to begin in that space. We then examined the hypothesis of the fire beginning there at approximately 6 a. m. to see if it could be consistent with later known events. A fire scenario was developed and calculations were examined to support the plausibility of the events and their duration. All of this

analysis will not be presented, but the results will be described.

Early dawn: Ignition (approximately 6 a.m.)

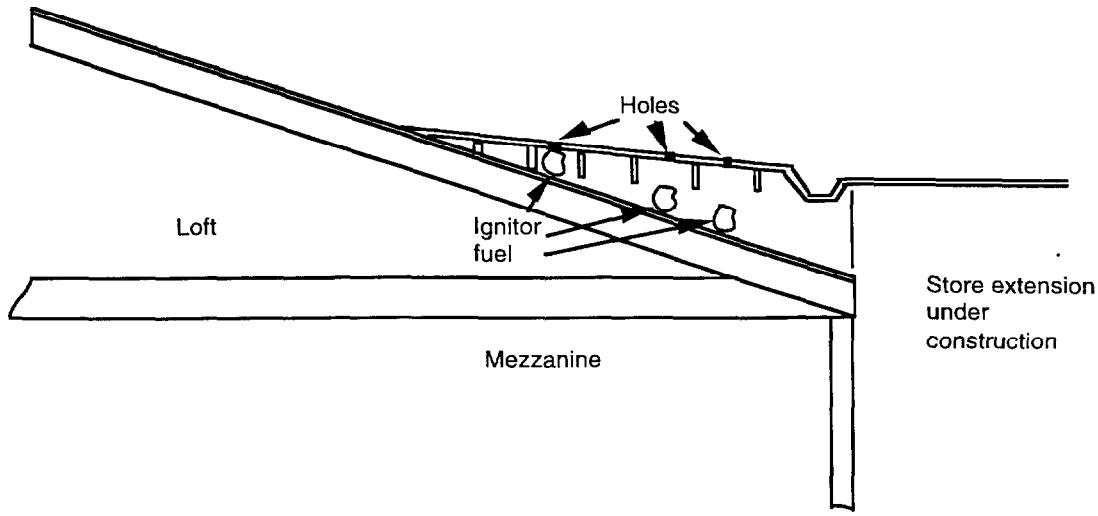

Figure 3. Flammable liquids soaked newspapers inserted into roof holes.

At approximately 6 a. m., an intentional fire is considered to have been set in the roof area adjacent to the construction of the building extension (Fig. 3). The fire is set by stuffing paper through holes in the new roof extension along with a liquid accelerant. The splayed roof extension has been built over the existing roof and forms a void space between the two roofs. The new roof is supported by rafters. The fire is set in channels of the wood rafters which extend between the primary wood trusses 4 and 5. Gaps under the rafters allow air to flow into the fire, but the space is mainly enclosed with temporary partitions at the wall adjacent to the new building extension. The accelerant soaked paper probably caused a fire of 100 to 500 kW in one or more rafter channels, involving no more than 1 m^2 (Fig. 4).

Under expected heat fluxes of 40 - 50 kW/m^2, the wood members would ignite in 30 seconds to one minute, and begin to contribute roughly 500 kW. The accelerant fire would probably burn-out in one to 2 minutes. The wood fire could progress to roughly 1000 kW, but then it would become limited in further growth due to combustion products filling this confined space.

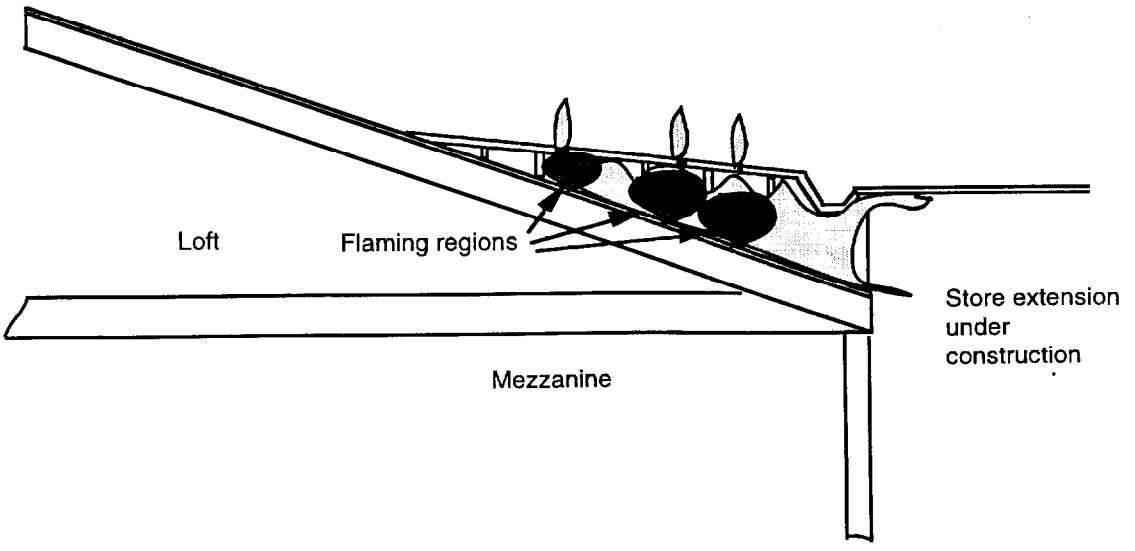

Figure 4. Ignition at approximately 6 a. m.

Smoldering Stage

Oxygen depletion would cause flaming to cease in about 1-2 minutes following wood ignition. However, sustained smoldering would be possible, especially in the smaller rafter spaces where radiant heat transfer would be high. Ohlemiller (1991) reports that sufficient radiant heat transfer is necessary to sustain smoldering in wood cavities. He also reports smoldering propagation rates of 1 to 6 cm/hr. Using the smaller value, smoldering can propagate through the old 3/4 inch plank roof in roughly 2 hours. Hence, a short time before 8:30, a hole would form between the loft and the roof cavity. With air velocity increased to 25 cm/s Ohlemiller (1991) found the smoldering wood would change to flaming combustion. Such velocities would be realized at the hole as air was naturally induced to flow from the loft into the hole. Hence flames would erupt in the false roof cavity space.

Onset of Flaming: Shortly before 8:30 a.m.

At approximately 8:30 am flames are observed in the mezzanine area at the wall and ceiling near truss 4. It is believed that this is due to the expansion of the flames as flashover caused a rapid rise in energy release

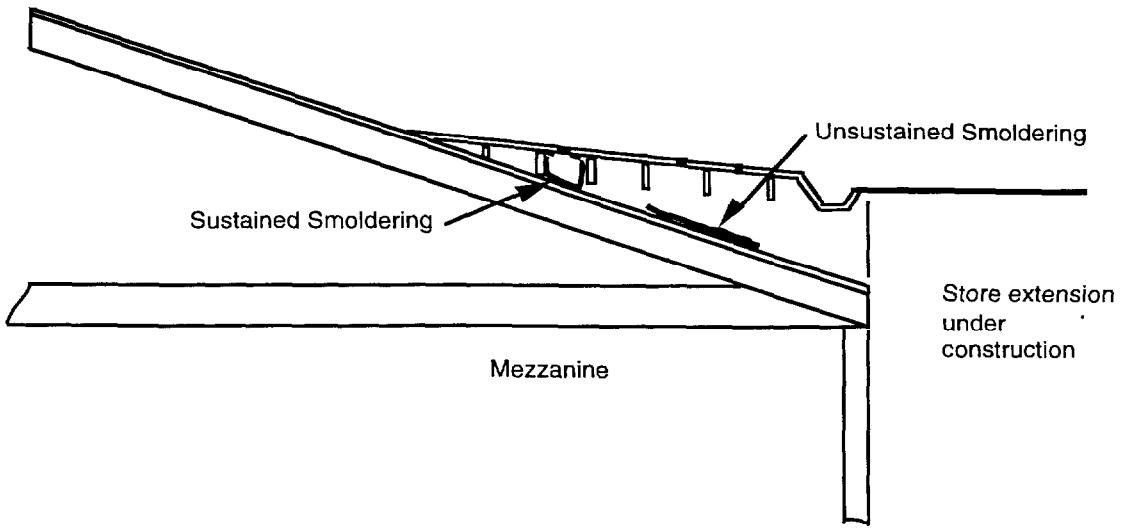

Figure 5. Smoldering combustion at approximately, 6:05 a. m.

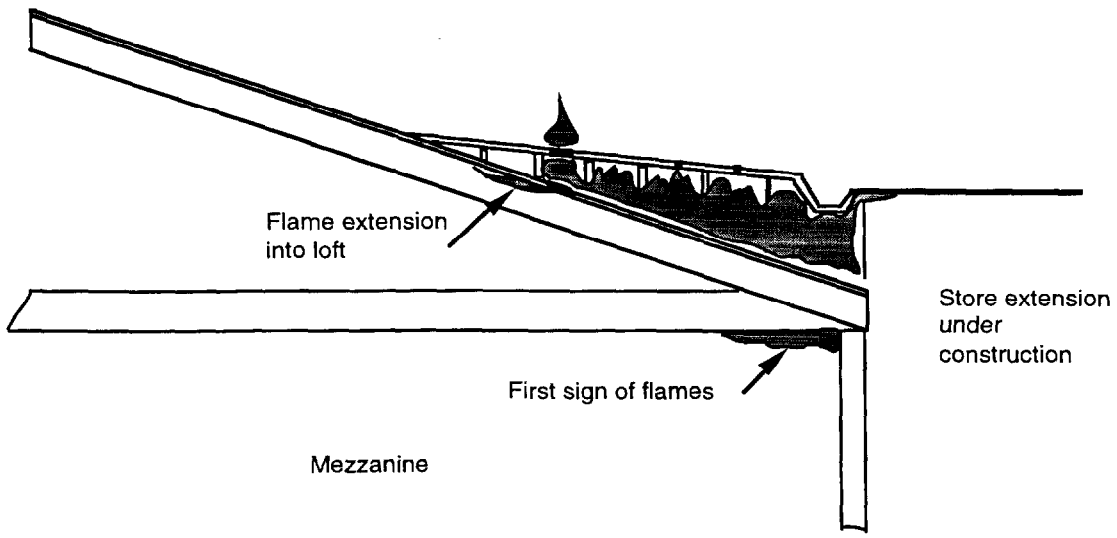

Figure 6. Flaming erupts in the roof cavity space shortly before 8:30 a.m.

rate in this confined space (Figure 6). The associated pressure increase forced flames through available void spaces. As the hole to the loft became larger, the increased air flow rate would also promote a larger flaming fire in the rafter spaces. The flow of the flaming combustion products would follow the rafter channel to the end points at trusses 4 and 5. Hence, the first flames are seen at an opening near truss 4. As the hole to the loft became even larger, flames would lap upward under the sloping wood ceiling of the loft. The person in the loft before this time would not have been aware of the fire since smoke would not permeate into the loft until the hole became large. In fact, he only saw flames when he descended to the machine room after being warned of the fire.

Evidence to support this scenario is shown in the photograph of Figure 7. The small white vapor plume rising from the roof indicates a hole in the roof. This hole is unlike the larger holes on the fire-wall protected side of truss 4 where grey smoke is emanating. Flames are seen to have emerged from the roof on the other side of truss 4 and above the first hole of the most confined rafter space as shown in Figure 3. This is the area that smoldering would have been sustained. The hole indicated by the white vapor plume is in the area of the larger void space where fire was likely initiated, but smoldering was not sustained.

Fire Growth in the Cock Loft

Flame spread would rapidly move from the hole, up and under the loft wood ceiling. It is estimated that flames would move from the hole region up and along the peak of the loft to truss 4 and through truss 5 in 2-3 minutes. This time was estimated from a flame spread model (Quintiere, 1994) using an ignition time of 30 s, and an energy release rate per unit area of 150 kW/m^2. This rapid spread (Figure 8) seemed incredulous; and, with the low confidence in flame spread calculations, an experiment was performed in a similar, but smaller loft. Flashover occurred in the experiment in approximately 1 minute. In the store loft, flashover was estimated to occur when the wood contribution is 6 to 12 MW in the section of the loft between trusses 4 and 6. The flame spread calculation indicated that this would occur in approximately 2 1/2 minutes. Full involvement was estimated to take up to 5 minutes more. Hence, from the onset of flaming at the hole, full involvement of the loft

Figure 7. The fire at approximately 8:50 a. m.

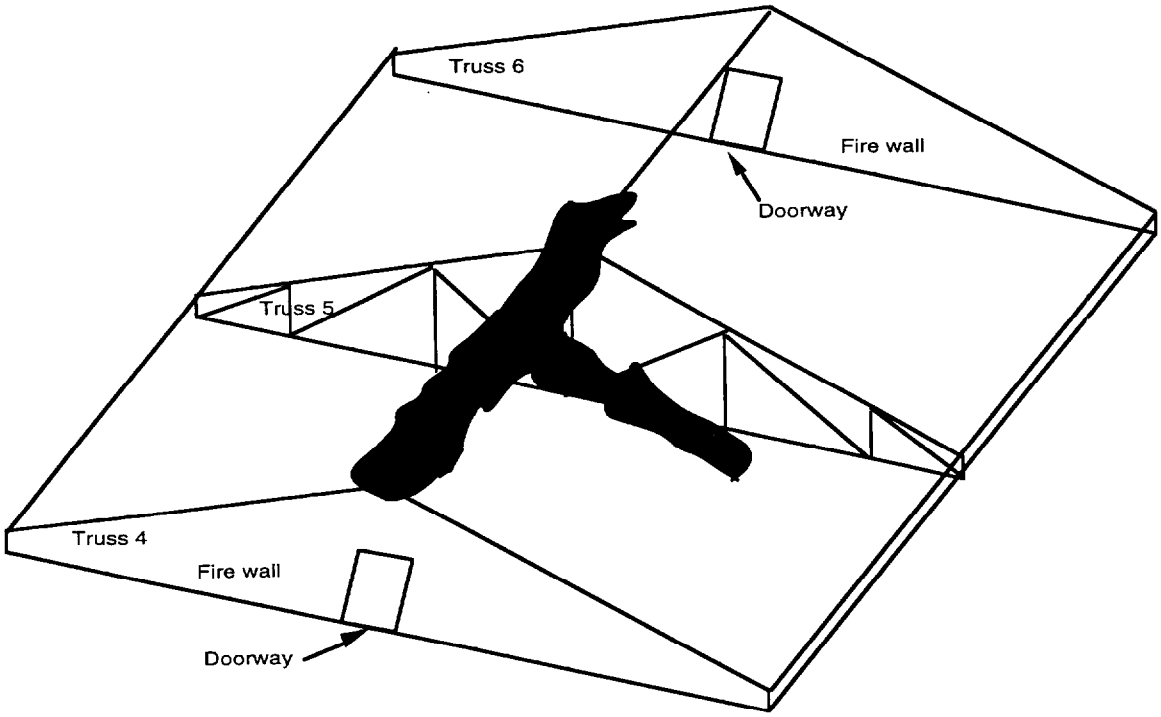

Figure 8. Fire growth in the loft at approximately 8:35 a. m.

section would take approximately 5 to 10 minutes. Because of the false roof sections and the truss fire-wall sections, the firefighters on the roof were unaware of the raging fire in the loft section below them.

Collapse of the Roof due to Truss Member Failure

If one assumes that the roof collapse is due to the failure of a truss member as a result of fire degradation, the burn through time of a member can be estimated. The fire exposure assumed is a fully involved loft with a 3 inch thick truss member within the flame. Using a mass burning rate per unit area of 11 g/m^2s, typical for wood under these conditions, leads to a burn through time estimate of approximately 35 minutes. This results in a truss member failure at 9:10 a. m. compared to the recorded roof collapse 5 minutes later.

Concluding remarks

This fire scenario was a complex series of phenomena that are not usually appreciated in the study of fire. Experienced fire investigators were not able to deduce this process. Yet relatively simple scientific analysis could produce a plausible and consistent series of events within the period of the recorded observations of this fire. Some may question the details, but the scenario fits the time-line of what is known and alleged.

Studies like this are very useful because they provide a test of science against the real world. The process can provide valuable answers to the investigator and valuable questions for the scientist.

References

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Discussion

Charles Scawthorn: I'm just asking what was the supposed motive for the defendant?

James Quintiere: It was allegedly paid arson because of business competition in that area.