SANTA ANA FIRE DEPARTMENT EXPERIMENT AT 1315 SOUTH BRISTOL, JULY 14, 1994

by

A.D. Putorti Jr., W.D. Walton,
W.H. Twilley, and S. Deal
Building and Fire Research Laboratory
National Institute of Standards and Technology
Gaithersburg, MD 20899
and
J.C. Albers
Fire Safety Division
Santa Ana Fire Department
Santa Ana, CA

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TECHNICAL NOTE

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A. D. Putorti Jr., W. D. Walton, W. H. Twilley, S. Deal, and J. C. Albers
Putorti, Walton, Twilley, and Deal are with the Building and Fire Research Laboratory at the National Institute of Standards and Technology. Albers is with the Fire Safety Division at the City of Santa Ana Fire Department.

Introduction

The Santa Ana Fire Department of Santa Ana, California, conducted a series of fire experiments in residences on South Bristol Street in the City of Santa Ana in July, 1994. NIST provided technical support, consisting of measurements of fire phenomena, to the fire department during these experiments. The experiment to be addressed in this report occurred on July 14, 1994, at 1315 South Bristol Street. The measurements included temperatures within various rooms, the velocity and temperature of outflowing gases, smoke detector activation time, sprinkler activation times, and time to full room involvement. Data were recorded every 5 seconds with a computerized acquisition system.

Structure

The building used for the experiment was a vacant, one-story, single-family dwelling. The building was of wood-frame construction, with gypsumboard interior walls and ceiling, and stucco-over-wire-mesh-and-paper exterior walls. The floors throughout the building, with the exception of the kitchen and bathroom, were constructed of hardwood. The floors in the kitchen and bathroom were covered with vinyl flooring.

The building had no basement, but rather a ventilated crawl space. The building was covered with a pitched roof, consisting of asphalt shingles over redwood planks.

The layout of the building is shown in Figures 1 and 2, along with interior dimensions. There were three bedrooms, a bathroom, a living room, a kitchen, and a garage. In order to simulate a second-story bedroom, a section of roof was removed, and a room was added above the living room. The addition was of wood-frame construction, with the interior walls and ceiling consisting of fire-rated gypsumboard 15.9 mm (0.625 inch nominal) thick. There was no exterior covering over the wood members of the second-story room.

Smoke Detector

A smoke detector was installed in the hallway outside the bedrooms in accordance with NFPA 72, *National Fire Alarm Code*. The detector was a single-station, battery-

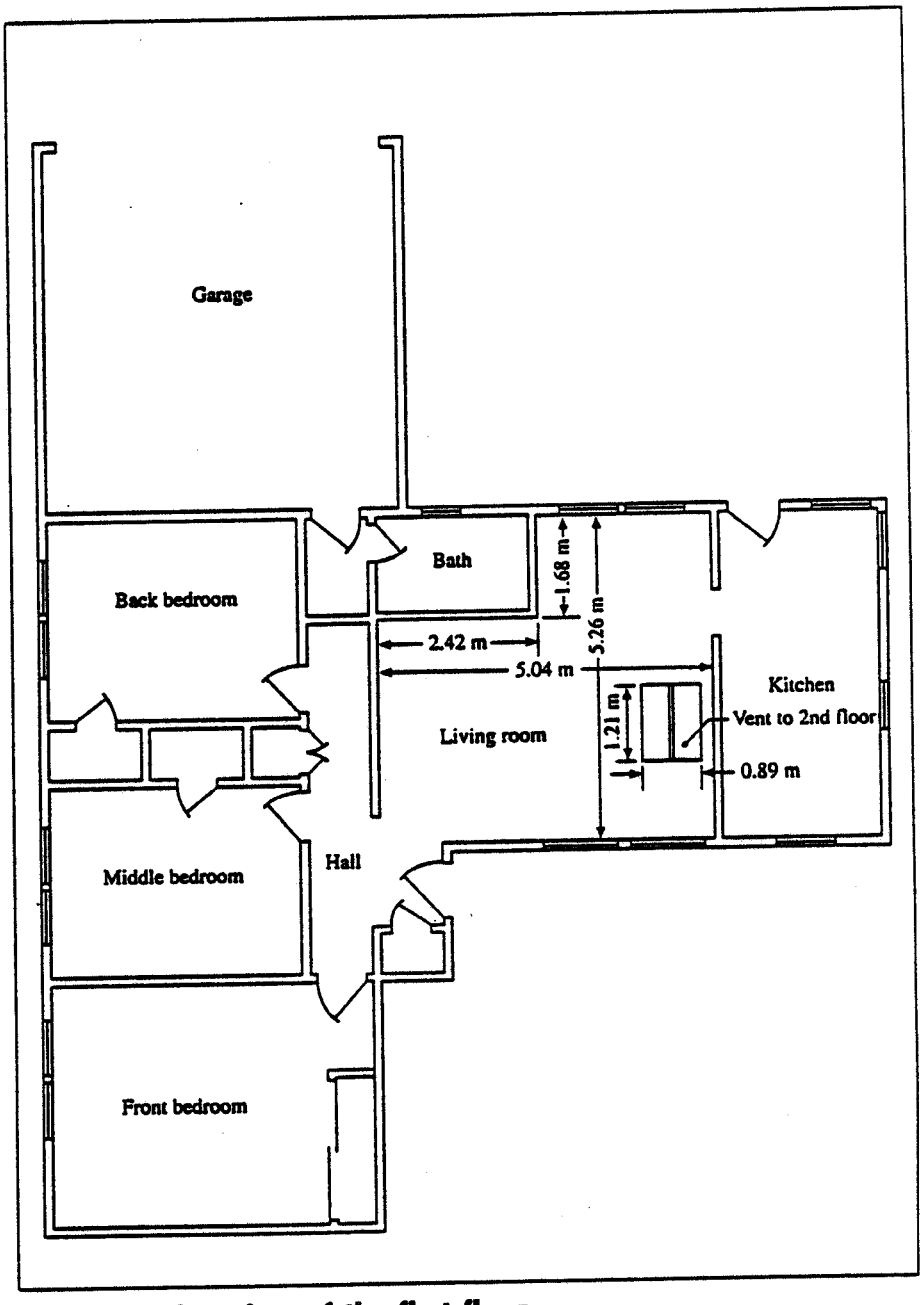

Figure 1. Plan view of the first floor.

powered, UL-listed, ionization-type smoke detector whose activation time was recorded manually by an observer equipped with a stopwatch. The location of the smoke detector is shown in Figure 3.

Sprinklers

In order to measure the activation time of typical residential-type sprinklers, one pendent sprinkler was installed in the ceiling of the living room, and one sidewall sprinkler was installed on the front wall of the living room. It should be noted that an actual residential sprinkler system installed according to NFPA 13D, *Sprinkler Systems in One- and Two-Family Dwellings & Mobile Homes*, would require more than one pendent or sidewall sprinkler in the living room.

The sprinklers had glass bulb elements with activation temperatures of 68°C (155°F). Each sprinkler was connected to a pressure switch with copper tubing. The tubing was pressurized with approximately 210 kPa (30 psi) of air pressure. When a sprinkler actuated, the signal was recorded on the data acquisition system and timed using an indicator light.

In addition to the sprinklers installed to measure activation time, two additional sidewall sprinklers, attached to a manually controlled water supply, were installed in the front wall of the fire room for experimental safety. Water was applied through the sprinklers for approximately 15 seconds at the end of the experiment before manual fire fighting, which extinguished the fire. The locations of the various sprinklers are shown in Figure 3.

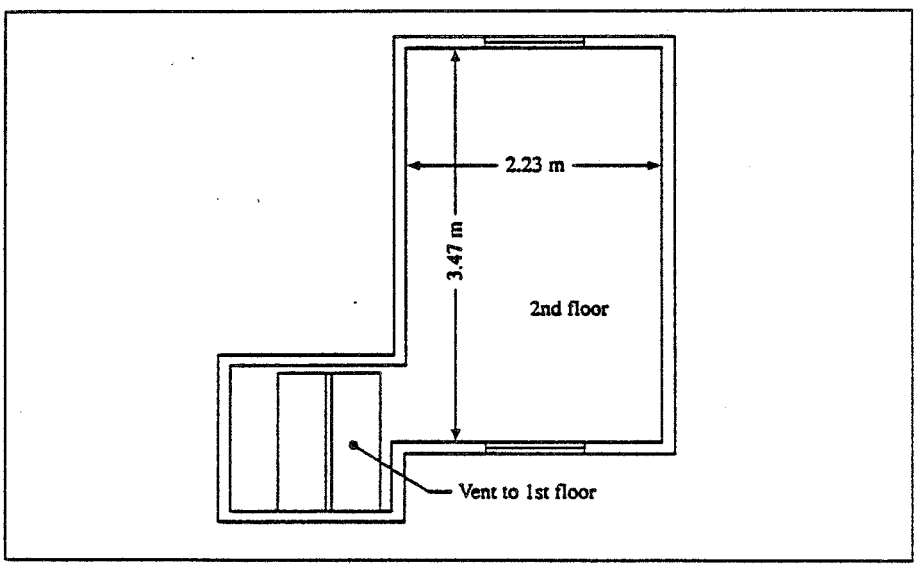

Figure 2. Plan view of the second floor.

Temperature Measurement

The temperatures were measured with 0.51 mm (0.02 inch) nominal diameter, bare-bead, type-K thermocouples. Floor-to-ceiling thermocouple arrays were located in the living room, the hallway, and the second-floor room, as shown in Figures 3 and 4. The elevations of the thermocouples above the floor are given in Table 1 for the living room and in Table 2 for the hallway and second floor.

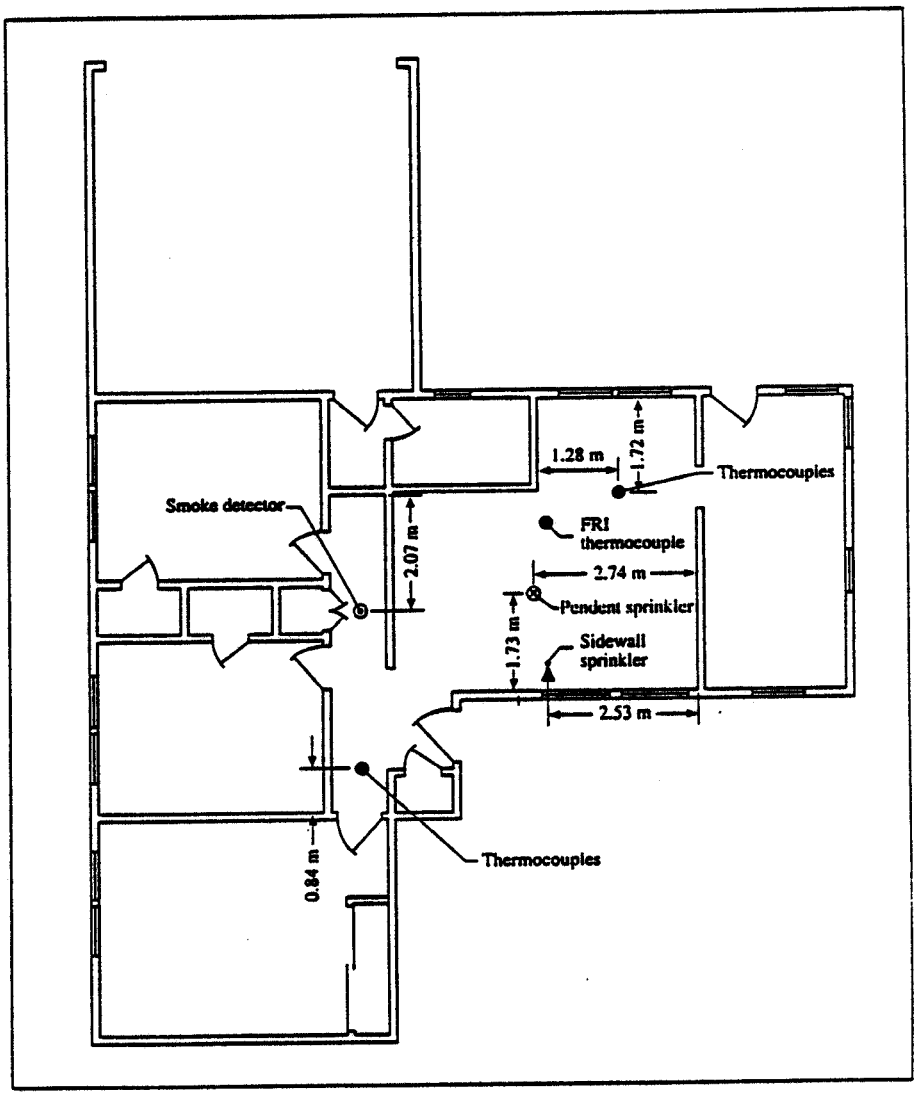

Figure 3. Instrument locations on the first floor.

TABLE 1
Living Room Thermocouple Elevations

Thermocouple Number	Distance from Floor (m)	Distance from Floor (ft)
1	2.41	7.89
2	2.36	7.73
3	2.28	7.48
4	2.21	7.23
5	2.13	6.99
6	1.98	6.50
7	1.83	6.00
8	1.68	5.51
9	1.53	5.02
10	1.38	4.53
11	1.23	4.04
12	1.08	3.54
13	0.93	3.05
14	0.78	2.56
15	0.63	2.07
16	0.48	1.58
17	0.33	1.08
18	0.18	0.59

TABLE 2
Hall and Second-Story Room Thermocouple Elevations

Thermocouple Number	Distance from Floor (m)	Distance from Floor (ft)
1	2.42	7.92
2	2.37	7.76
3	2.29	7.51
4	2.22	7.27
5	2.14	7.02
6	1.99	6.53
7	1.84	6.04
8	1.69	5.55
9	1.54	5.05
10	1.39	4.56
11	1.24	4.07
12	1.09	3.58
13	0.94	3.08
14	0.79	2.59
15	0.64	2.10
16	0.49	1.61
17	0.34	1.12
18	0.19	0.62

TABLE 3
Window Thermocouple Elevations

Thermocouple Number	Distance from Top of Window (m)	Distance from Top of Window (ft)
1	0.15	0.49
2	0.30	0.98
3	0.45	1.48
4	0.60	1.97
5	0.75	2.46
6	0.90	2.95

Thermocouples were located within 20 mm (0.79 in) of the pendent and sidewall sprinklers used to measure activation time. A thermocouple was located in a sheet of crumpled newspaper located on the floor near the television set, as shown in Figure 3. This thermocouple was used to detect ignition of the newspaper, an indication that full room involvement had occurred.

An array of thermocouples was located in the centerline of the open front window of the second-story room. The elevations of the thermocouples, as measured from the top of the window, are listed in Table 3.

The uncertainty in temperature measurement is ±2.2°C (±4.0°F), as derived from the thermocouple wire manufacturer. The uncertainties in the thermocouple locations are estimated at ±0.01 m (0.4 inch).

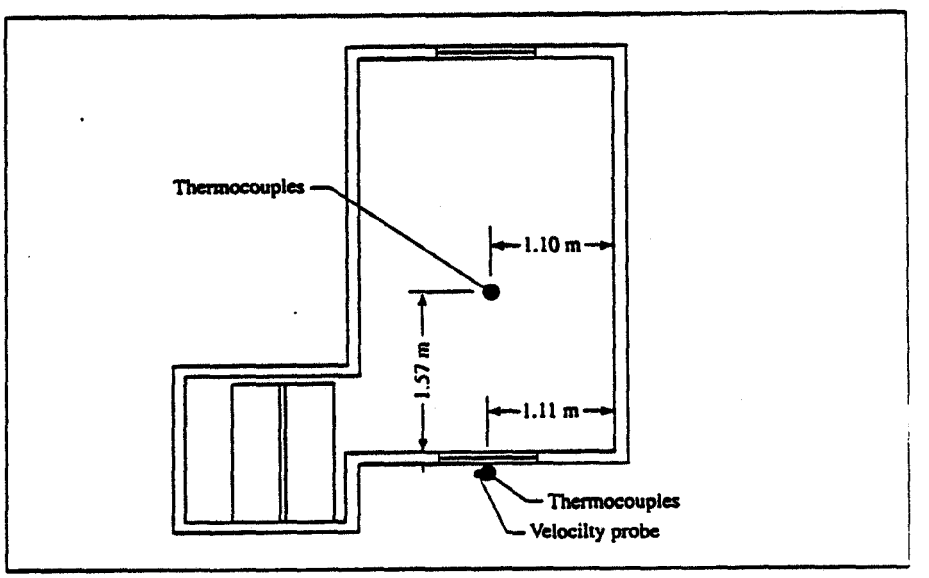

Figure 4. Instrument locations on the second floor.

TABLE 4
Fuel Load

Item	Mass (kg)	Weight (lb)
Mattress 1	25.9	57.1
Mattress 2	14.5	32.0
Mattress 3	14.5	32.0
Mattress 4	22.7	50.0
Mattress 5	22.2	48.9
Box Springs	23.6	52.0
Couch 1	52.2	115.1
Shade	0.5	1.1
Bed Clothes	19.1	42.1
Pillows	7.7	17.0
Television	71.7	158.1
Couch 2	54.4	120.0
Bed Frame (wood)	6.4	14.1
Bunk Bed Frames (wood)	54.4	120.0
Clothing	151.0	332.9
Total	552.0	1,217.0

Velocity Measurement

The gas velocity in the front second-story window was measured with a bidirectional probe connected to a differential pressure transducer. The bidirectional probe was located 0.15 ±0.01 m below the top of the window approximately 25 mm (0.98 inch) from a thermocouple. The uncertainty for the gas velocity measurements is ±0.1 m/s (0.3 ft/s), as derived from manufacturer data for the differential pressure transducer.

Fuel Load

The fire room was furnished by the Santa Ana Fire Department to simulate high-fuel local conditions. The furnishings consisted of two wood-frame bunk beds (mattresses without box springs), a doube bed (mattress and box spring), pillows, two couches, a television set, a lamp shade, and assorted articles of clothing. The total mass of the contents was 552.0 kg (1,217 lb) with an uncertainty of 10% estimated for the scale used in the experiments. The masses of the individual components are listed in Table 4. Figure 5 shows the location of the furniture in the room.

In addition to the contents of the room, there was an ignition source: a plastic waste basket 0.255 m high by 0.255 m wide by 0.188 m deep (10.0 by 10.0 by 7.4 inches). The wastebasket contained a total of eight 2-quart waxed cardboard milk cartons. Two cartons were placed vertically in the basket, with another placed inside each of the two, forming two double-layered, vertically oriented, open cartons. Inside each of the vertical cartons was placed the torn pieces, nominally 0.0010 m^2 (1.6 $inches^2$), of two identical cartons. The wastebasket was placed between the two sets of bunk beds

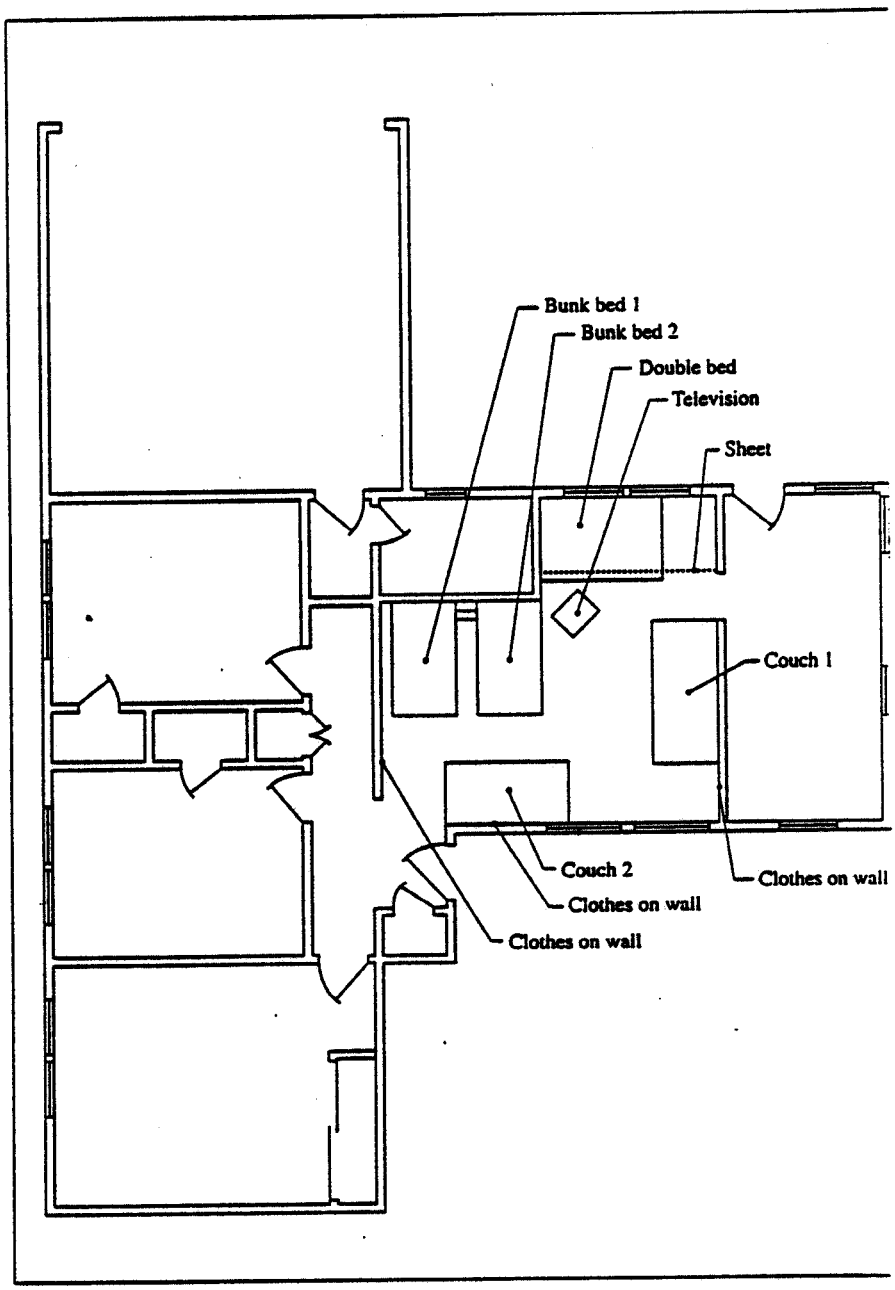

Figure 5. Plan view of fire room with combustible contents.

TABLE 5
Sequence of Events

Elapsed Time (s)	Event
0	Ignition
85	Smoke detector actuation
100	Pendent sprinkler actuation
105	Sidewall sprinkler actuation
110	Transition to full room involvement
360	Water application begins

and ignited by removing one torn piece from each of the two vertical cartons, igniting it, and dropping it into the carton.

Results

The sequence of events for the experiment is given in Table 5, with an estimated uncertainty of ± 2 seconds.

The temperatures measured within the living room (fire room) are shown in Figure 6. The data are presented for various distances from the floor in order to simplify the graphs yet show the temperature profile within the room. Due to the failure of the living room thermocouple tree shortly after full room involvement, the temperature data are available only up to 120 seconds. The thermocouple near the pendent sprinkler and on the floor in the newspaper, however, operated throughout the experiment. The data from these thermocouples are shown in Figure 7. The data from the thermocouple near the sidewall sprinkler, also shown in Figure 7, ends at approximately 120 seconds due to thermocouple failure.

The temperatures measured within the hallway are shown in Figure 8. As in the case of the fire room, temperatures are given versus time for selected heights above the floor.

Temperatures measured in the second floor room are graphed in Figure 9. The temperatures of gases entering or leaving through the open window at the front of the room are shown in Figure 10.

The velocity of the outflowing gases measured by the bidirectional probe at the front window of the second-story room is shown in Figure 11.

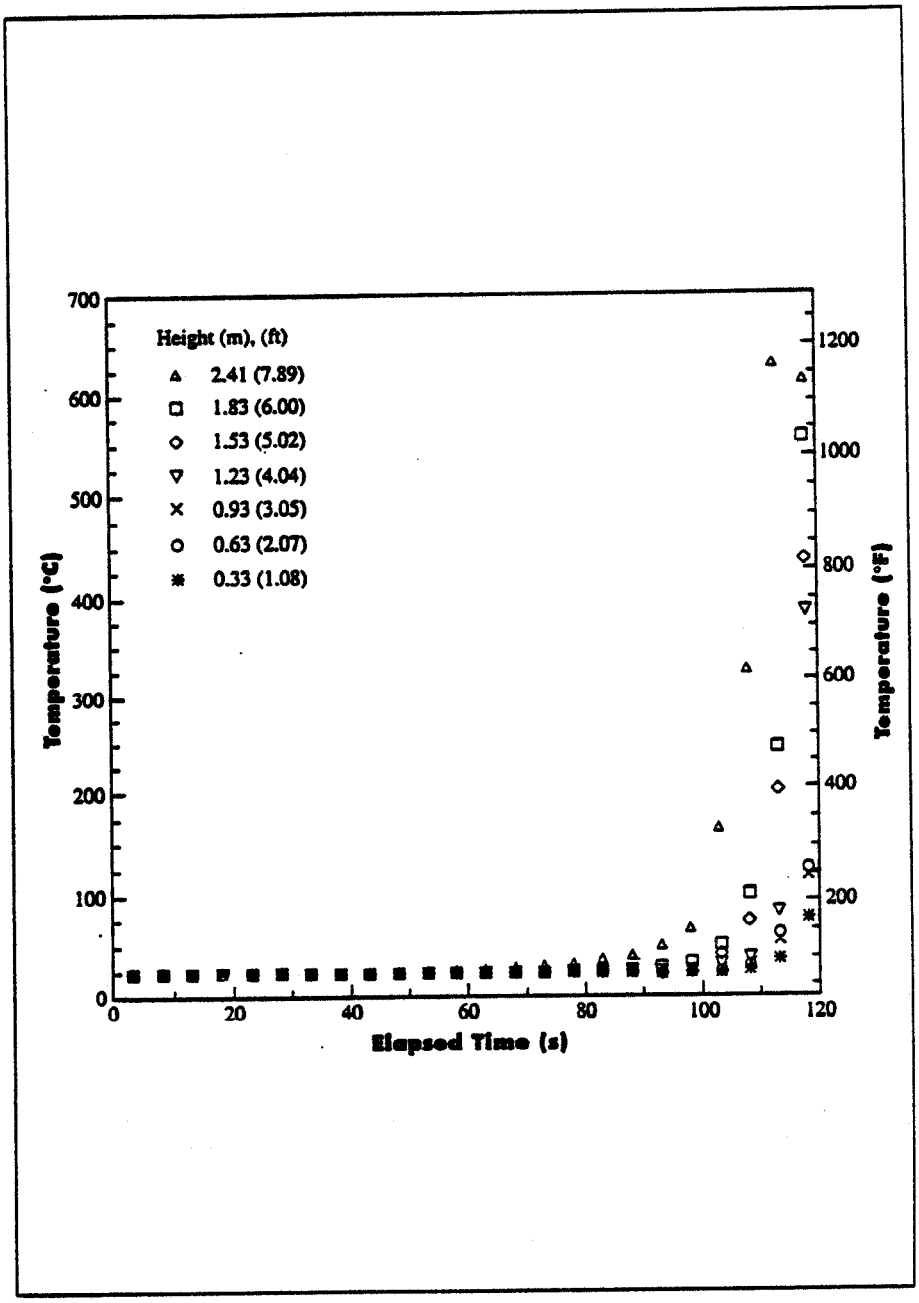

Figure 6. Temperatures in the living room.

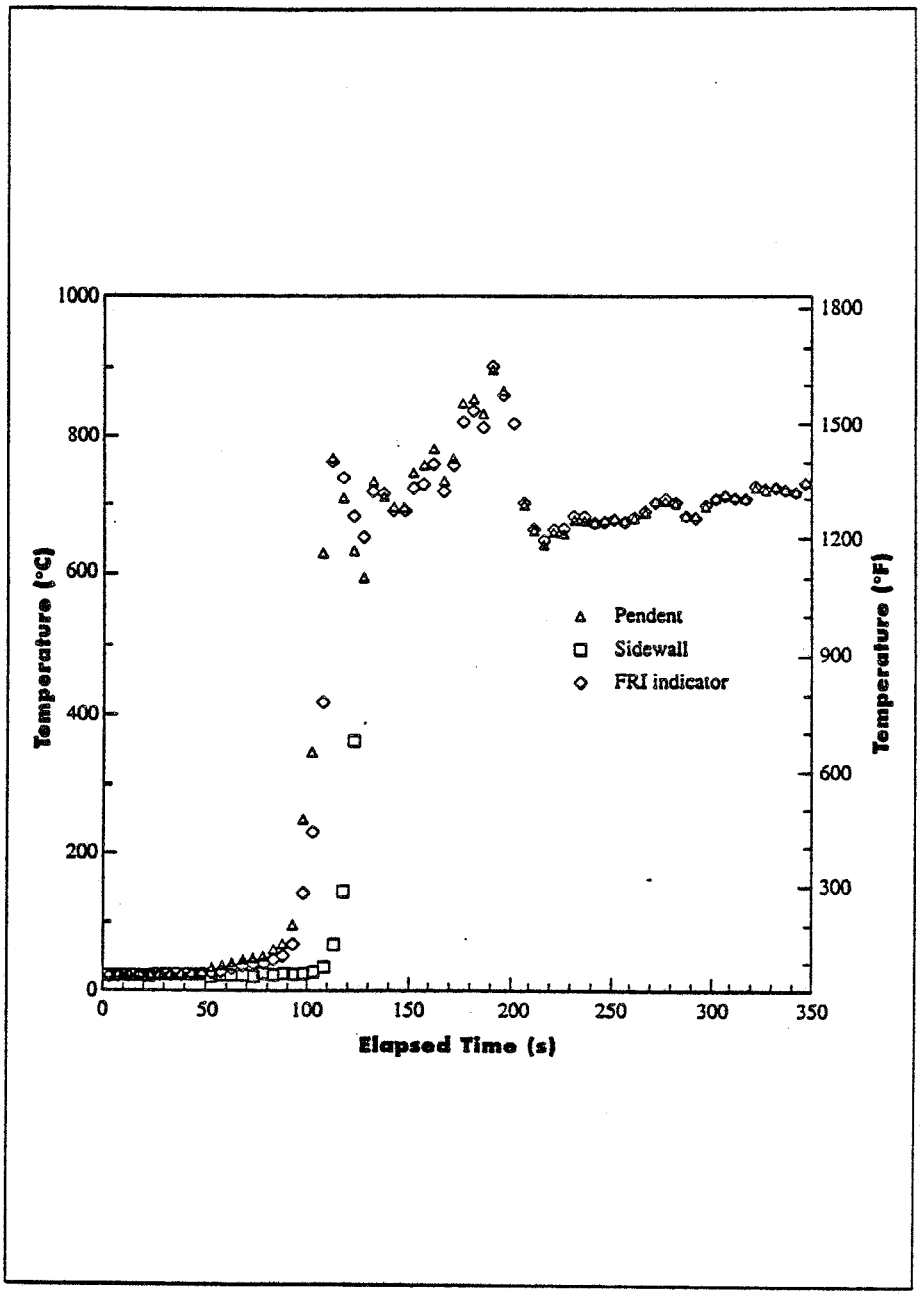

Figure 7. Single thermocouple temperatures in the living room.

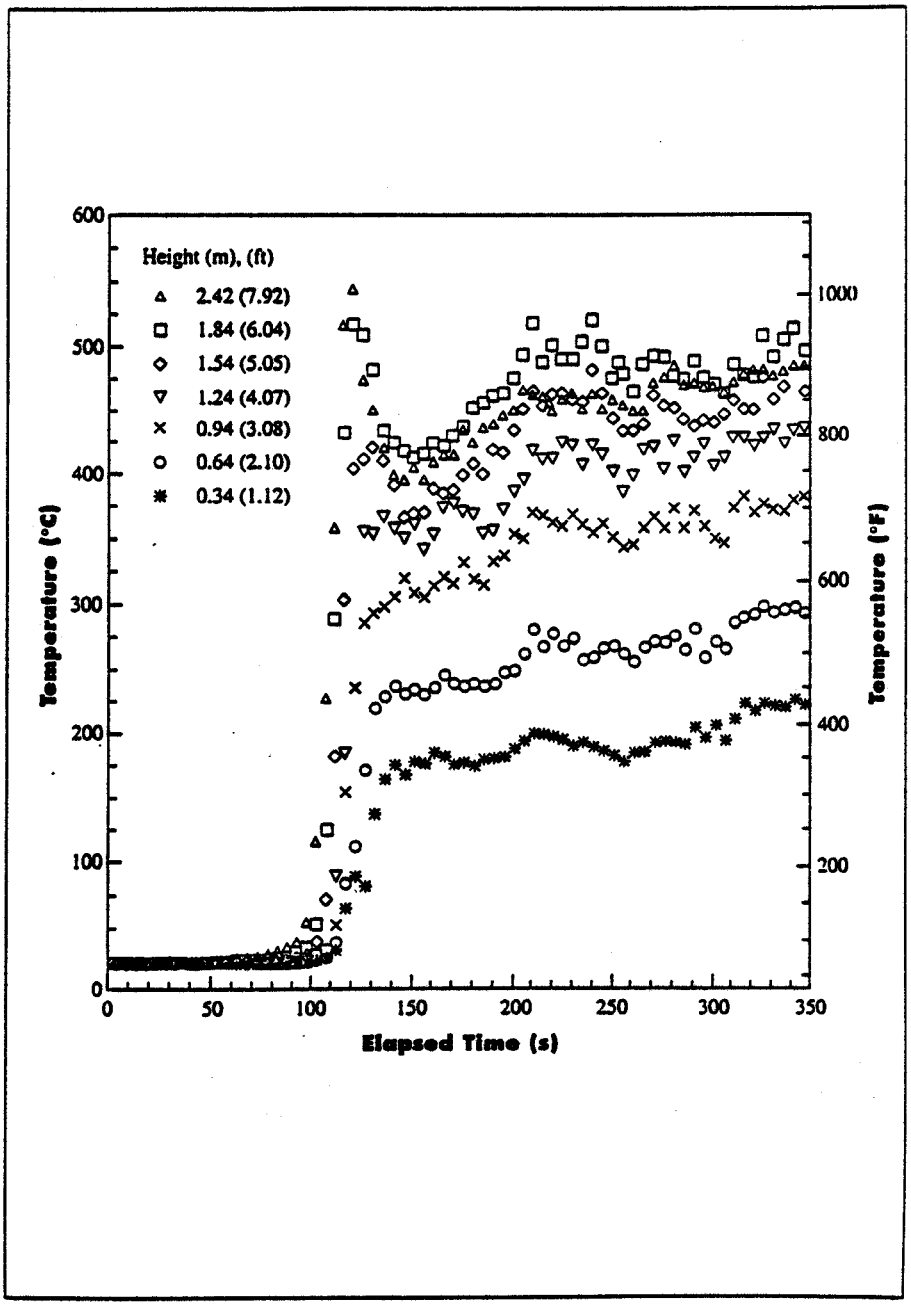

Figure 8. Temperatures in the hall adjacent to the living room.

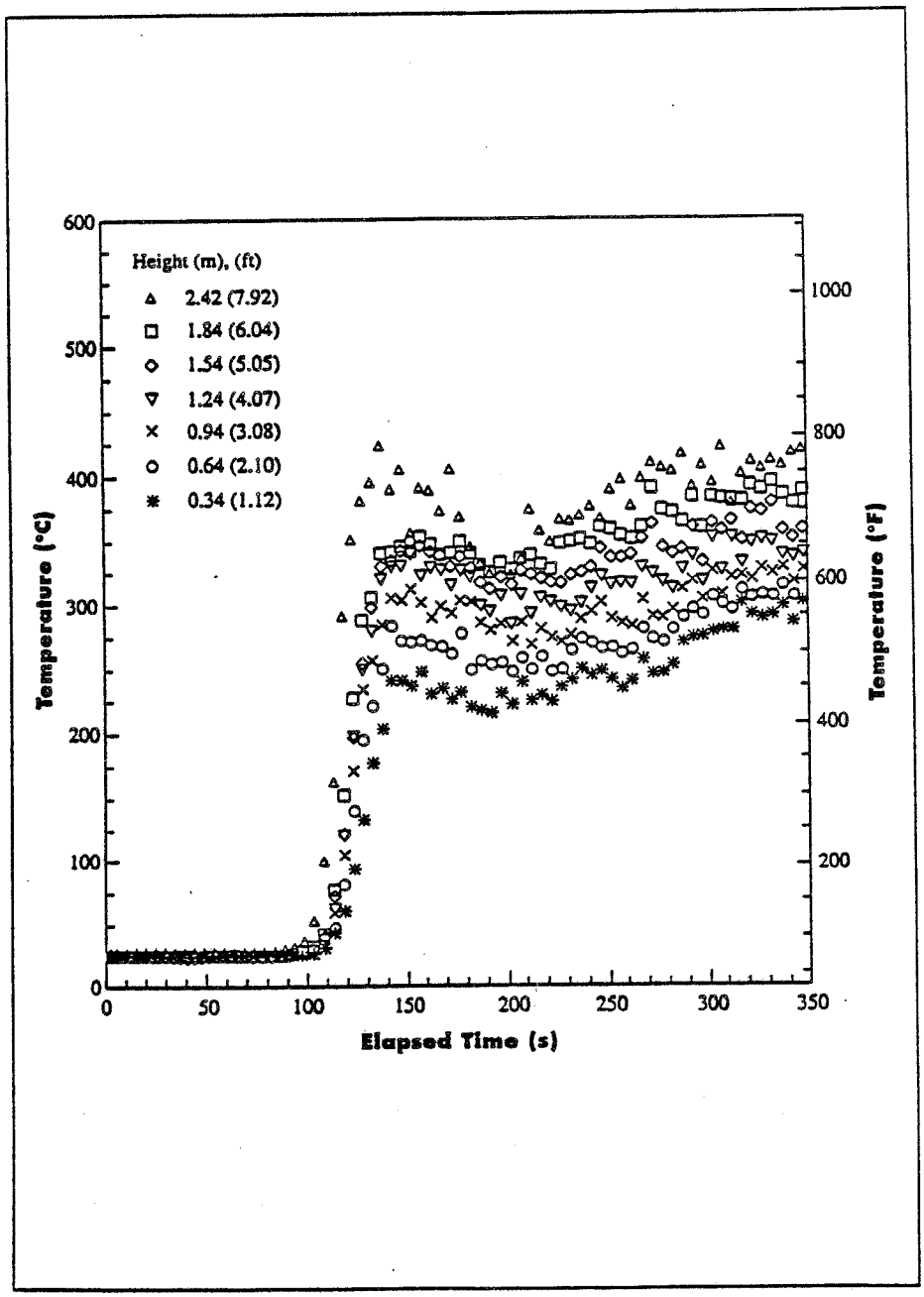

Figure 9. Temperatures in the second story.

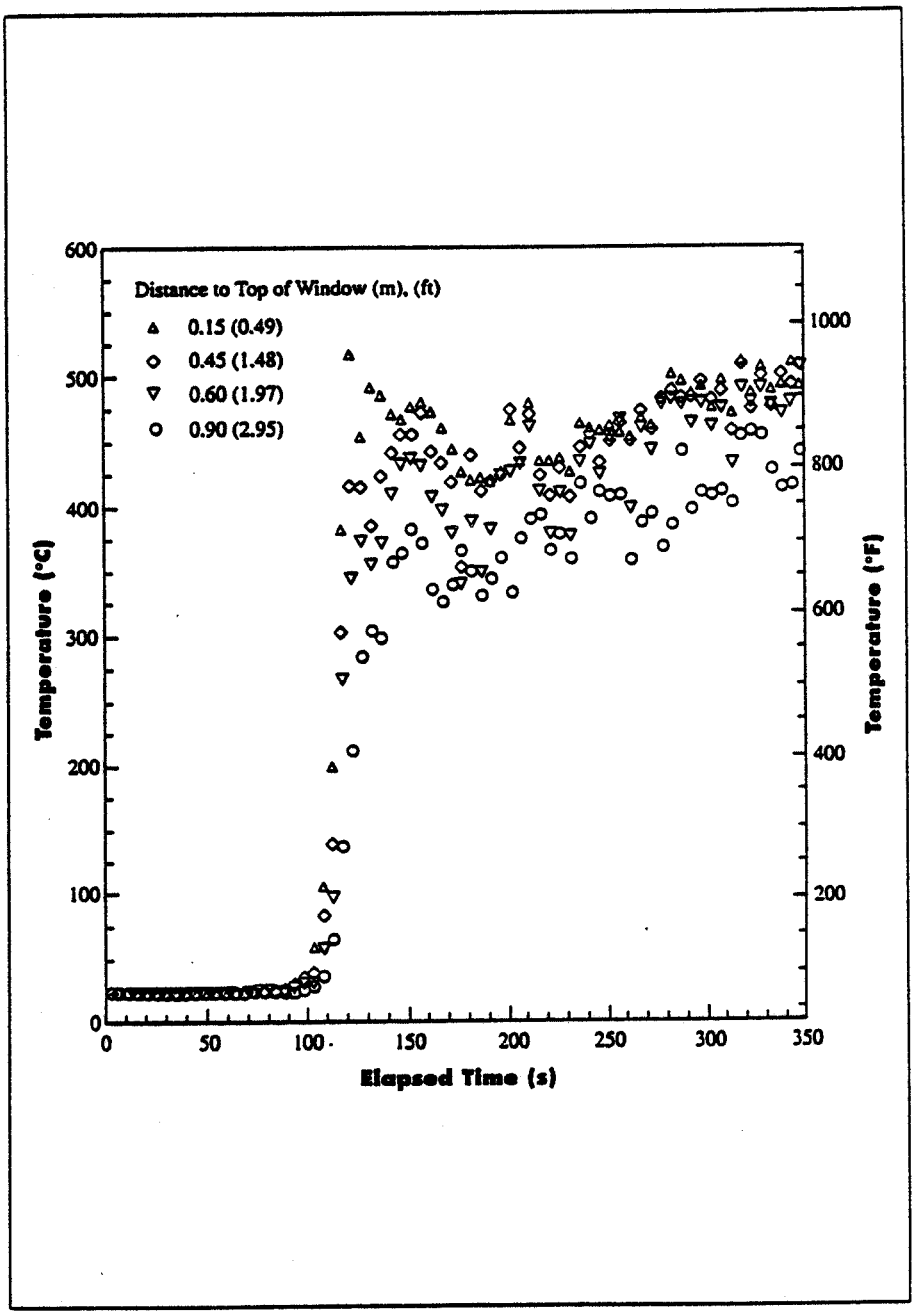

Figure 10. Temperatures in the second-story front window.

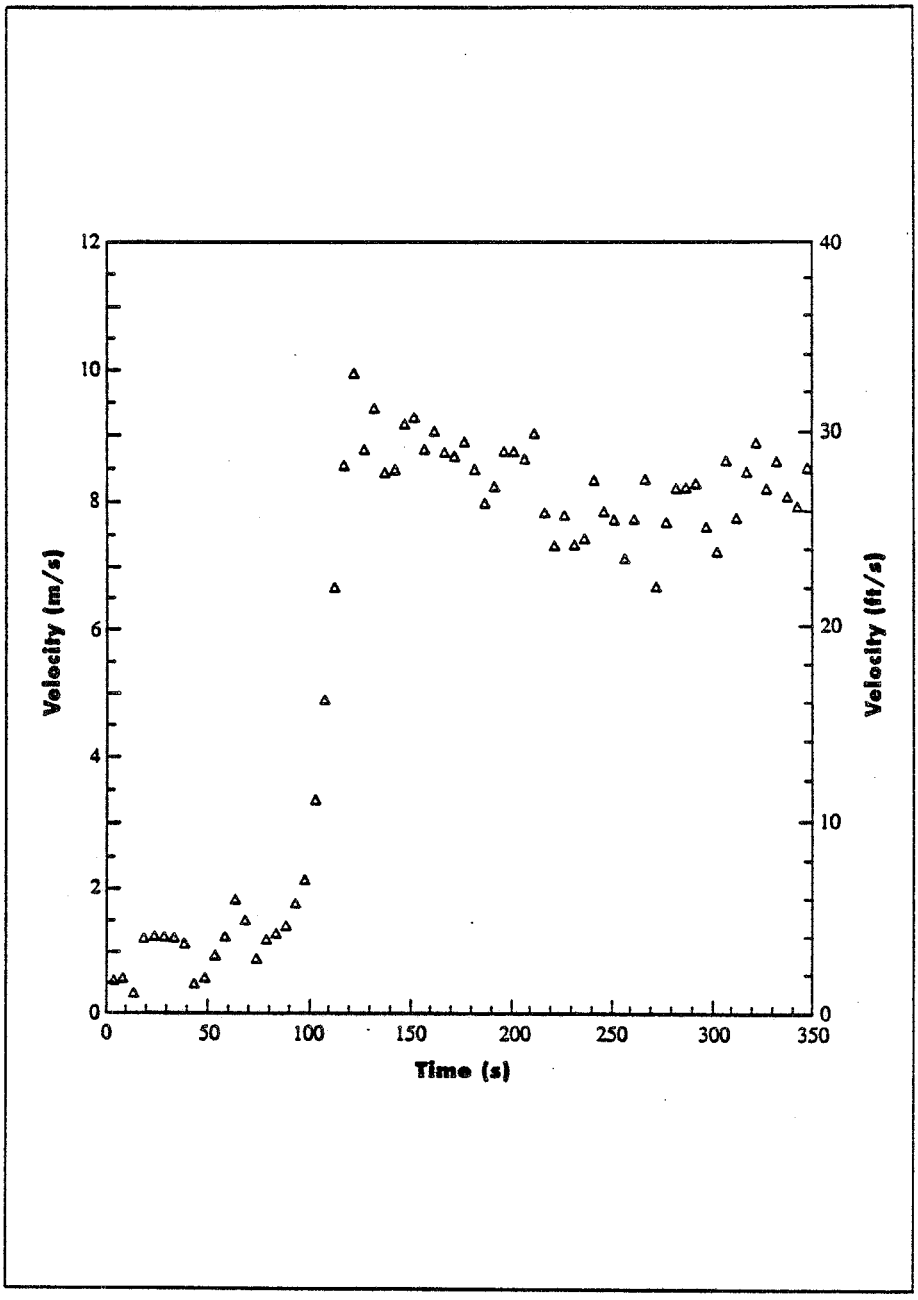

Figure 11. Velocity of the gases at the second-story front window.