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RESIDENTIAL COMBUSTION VENTING FAILURES - A SYSTEMS APPROACH

A SURVEY OF FIREPLACE SPILLAGE INCIDENTS IN TWENTY-FOUR HOUSES

FINAL REPORT

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SUMMARY

This report describes a research project that surveyed the frequency and duration of combustion gas spillage from conventional fireplaces in 24 houses located across Canada. The project was managed by Canada Mortgage and Housing Corporation (CMHC), with funding from the CCRL/ERL/CANMET of Energy, Mines and Resources Canada (EMR). This work was a continuation of a multi-part research study, begun in September, 1985 by the Scanada-Sheltair Consortium, on behalf of CMHC, entitled "Residential Combustion Venting Failures - A Systems Approach."

Eight houses were selected in each of the three regions: Vancouver, British Columbia; Winnipeg, Manitoba; and Ottawa, Ontario. Houses were selected on a random basis from a sample of householders who claimed to frequently operate their fireplaces. The house sample included 12 open masonry fireplaces and 12 fireplaces with conventional glass doors.

Fireplace spillage detectors were hung on the face of the mantle (or equivalent) above the centre of each fireplace. The spillage detectors consisted of a smoke detector and carbon monoxide detector, each wired to an event recorder and a time totalizer. Householders kept track of the number of fires and the length of each fire. After installation of the detectors, data was collected on house characteristics, including airtightness levels and maximum house depressurization created by operation of exhaust appliances. Tests of the venting systems in each house revealed that seven houses had venting problems involving combustion appliances other than the fireplace. A common problem was excessive spillage (greater than 30 seconds) from furnace or water heater chimneys under worst case conditions. Five of these houses also exceeded the house depressurization limits established for safe chimney operation.

The monitoring period lasted approximately 90 days for each house. During this period, householders used their fireplaces an average of 24 times. All together, the householders burned 566 fires for a total burn time of 2,435 hours. The average duration of a single fire was 4 hours and 20 minutes.

Data collected by the spillage counters appeared to provide a reliable record of spillage events, with a few exceptions. Some corrections to the data were required on three spillage detectors to account for electrical power failures. In two cases, the carbon monoxide (CO) detector was found to have been influenced by CO generated from sources other than the fire (from a car idling in an attached garage and from cigarette smoking during an evening party in one of the houses).

An analysis of the data collected by the spillage detectors indicated that spillage of combustion gases is a frequent event for conventional fireplaces. All except two houses experienced more than one smoke spillage event, and in most cases the numbers were surprisingly high. One house experienced 2,084 spillage events, and four other houses recorded from 248 to 653 counts. The average length of a smoke spillage event was fairly consistent from house to house, averaging 12 seconds.

The average number of CO spillage events was much smaller than for smoke spillage. However, the duration of CO spillage was much longer than for smoke, with an average CO spill length of 2.7 minutes. In part, the lower frequency and longer duration of CO spillage can be explained by the design of the detectors. (Smoke detectors responded much faster than CO detectors and recorded more of the short-term spills.) The lower number of spillage events for the CO detector may also reflect the 50 ppm sensitivity limits for the detectors. Many of the fireplace spills evaluated during testing of prototype detectors seemed to be in the 20 to 50 ppm range, too low to be detected.

As was the case with smoke detectors, a good correlation existed between the number of CO spillage events and the total CO spillage duration. Several houses with numerous smoke spillage events did not record high quantities of CO spillage. These houses emphasize the value of a dual-detector system which uses both smoke and CO as indicators of spillage occurrences.

Spillage time for each fireplace, based on either smoke or CO detection, was calculated and presented as a percentage of the total burn time. On the average, the 24 fireplaces spilled for 2.5 percent of their operating time. Spillage times ranged from 0.07 percent to 3.91 percent of the burn time for all but two houses in the sample. The two exceptional houses had spillage to burn rates of 18.19 percent and 14.4 percent. With these two anomalous houses removed from the sample, the average spill time for fireplaces amounts to 1.2 percent of their operating time.

No specific features of the fireplaces or houses appeared to correlate with the propensity towards spillage events. It is suspected that the chimney and firebox design and fireplace operation could be significant variables. These factors were not investigated.

CONTENTS

1. INTRODUCTION AND BACKGROUND

This is a report on a research project that surveyed the frequency and duration of combustion gas spillage from conventional fireplaces, in 24 houses, located in three regions of Canada. The project was managed by Canada Mortgage and Housing Corporation (CMHC), with funding from the CCRL/ERL/CANMET of Energy, Mines and Resources, Canada. This work was a continuation of a multi-part research study begun in September, 1985, by the Scanada-Sheltair Consortium on behalf of CMHC - entitled "Residential Combustion Venting Failures - A Systems Approach" (Ref. 1).

Most of the research conducted by the Consortium on Residential Combustion Venting Failures was completed by November, 1986. This previous research work included an initial survey of fireplace spillage incidents, in 5 houses, as part of a much larger survey into venting failures events in Canadian housing, particularly furnaces and water heaters. The initial fireplace survey had been limited in scope and duration because fireplaces required more complicated detectors, relative to the other types of combustion appliances in houses. The budget was inadequate to cover both the costs of these detectors, and their installation in a sufficiently representative sample of housing. For these reasons a decision was made to conduct a second survey of fireplace spillage incidents over the 1986/87 heating season, incorporating a larger sample of 24 houses, as well as an improved detector design.

This report describes the selection of 24 houses for a second fireplace survey, and the design, fabrication, testing, and installation of the new detectors. The report analyzes the results of the spillage monitoring, and makes conclusions about the frequency and duration of fireplace spillage events.

2. PROCEDURE

2.1 Selection of Houses

Eight houses were selected in each of three (3) regions:

- Vancouver;
- Winnipeg; and
- Ottawa.

These regions were selected for their variety of climates and housing stock. Previous surveys in these regions had produced a data-base of houses, and an experienced, well-equipped team of research firms. Eastern Canada was not included, since previous survey data had indicated that fireplace use in this region has been almost totally supplanted by the more energy-efficient wood burners.

Each of the three firms responsible for installation were provided with instructions for selecting houses. Houses were to be chosen so as to include a fairly representative collection of fireplaces and housing types for their region; primarily houses with open masonry fireplaces, but also one or two fireplaces with glass doors and ideally one fireplace in an exceptionally tight house (such as an R2000 house).

Regions were provided with a sample advertisement for posting in their neighborhood newspaper. This ad was run in Vancouver and in Ottawa, where it generated 30 to 40 responses in each location. This approach ensured a sample of "avid" fireplace users. In Winnipeg, houses were selected from the existing data base on the Canada-wide Survey, which listed householders who claimed to use their fireplace three (3) or more times per week. Approximately 38 of these householders were telephoned in order to select 8 houses with suitable fireplaces, where householders were willing to participate.

Most householders were compensated through the provision of firewood (1/2 cord hardwood, cut, dried, and delivered), although some received an

equivalent cash payment. In return, the householder was requested to permit researchers to mount a detector on their mantle for approximately three (3) months, operate their fireplace at least twice a week, and record the number of fires. Householders signed formal agreements with the regional firms.

2.2 Design of the Fireplace Spillage Detectors

The spillage detectors used previously (during the initial survey in 1986) consisted of a smoke detector and a carbon monoxide (CO) detector, each wired to a common event recorder and time totalizer. The event recorder kept track of the number of spillage occurrences (how often), and the time totalizer kept track of the duration of spillage (how long).

For purposes of this new fireplace survey, it seemed worthwhile to separately log CO and smoke spillage, so as to better measure the degree of health risk associated with spillage, and to better evaluate the effectiveness of the different types of detectors during venting failures. Consequently the new design of the detector included four (4) counters:

Counter 1: Smoke and/or CO duration
Counter 2: Smoke spillage events
Counter 3: CO spillage duration
Counter 4: CO spillage events

The first counter (1) records both CO and smoke spillage time, giving an indication of the total spill time irrespective of spillage composition. By subtracting Counter 3 from Counter 1, the total 'smoke-only' spillage duration can be determined.

The time totalizers were selected to provide an exact record of duration, dividing time into 10 second segments. A rough wiring diagram for the counters is presented in Appendix 2.

A schematic of the CO and smoke detector counter and timer circuits is also presented in Appendix 2, along with the input circuits and switches. Circuit boards included light emitting diodes (LED), indicating current draw by the counters, to facilitate trial tests of each detector.

Consideration was given to adding a fifth counter to the detector to keep track of fireplace usage time. Thermodisc probes were inserted into the smoke chamber of the firebox of a test fireplace, and were found to respond quickly to fire use, making possible the automatic recording of fireplace use. However, concern remained that temperatures in this location may exceed the limit for the copper (capillary) tubes used by the Thermodisc probes. Also, the probes complicated installation and could have interfered with fireplace use. Eventually it was decided to prepare booklets for householders to use, and simply ask householders to keep track of numbers of fires and typical lengths of fires. More accurate statistics did not seem necessary, and in the end, this approach proved satisfactory.

Additional field research was carried out to confirm the need for both a CO and a smoke detector, and to determine an optimum location for the detector.

The requirement for both CO and particulate spillage detectors had been suggested during the evaluation of warning devices for fireplaces, on Project 5 of "Residential Combustion Venting Failures" (Ref. 1). A similar series of field tests was conducted as part of the detector design for the second fireplace survey. A NOVA ANALYTICAL CO analyzer (Model # DB200) was used to monitor CO production, while testing various types of wood combustion gas spillage. Comparisons were made between CO concentrations and smoke detector sensitivity. As previously documented, the low ember fires were found to produce significant quantities of CO (20 to 200 ppm), without sufficient particulate for triggering the smoke detectors. This confirmed the previous conclusion that a combination of detectors was essential for monitoring fireplace spillage.

The optimum location for the detectors was, as before, determined to be on the face of the mantle (or equivalent) with each detector hung on a vertical surface. Surprisingly, the traditional horizontal mounting of the smoke detector did not prove as sensitive to smoke as the vertical mount position, since the vertical position permitted a greater flow of smoke into the ionization chamber. It was decided to mount the two alarms side-by-side, rather than vertically aligned, so as not to disturb flow to either detector.

Previous work with fireplace spillage detectors had shown that the counters and circuit boards were quite sensitive to movement and handling - sometimes causing counters to count during mounting or dismounting. Consequently the new design packaged the circuit board and counters in a steel box (25 mm X 250 mm X 200 mm). The detectors were securely screwed to the face of this box. Rubber feet kept the box away from the surface of the mantle or wall. The power cord entered through a shock-resistant plug in the side of the box. A window was cut along the upper perimeter of the box so that the counters were visible without dismantling the box. It was not essential that counters be visible to householders, but it greatly assisted the quality control testing and improved the versatility of the detectors for use in future studies. The LED indicator lights were visible through the window, but only at an angle (so as not annoy householders).

Mechanical counters were employed as a relatively low-cost method of reliably storing data. Although mechanical counters draw more power than the electronic counters, no data is lost in the event of a temporary power outage.

Each detector was provided with a 2 metre extension cord (in addition to its 2 metre mother cord) to reach far-away outlets. An octopus plug was provided to ensure that householders had no need to unplug the detector to obtain power for some other appliance. (Unplugging a detector would cause the vent counters to add one event.)

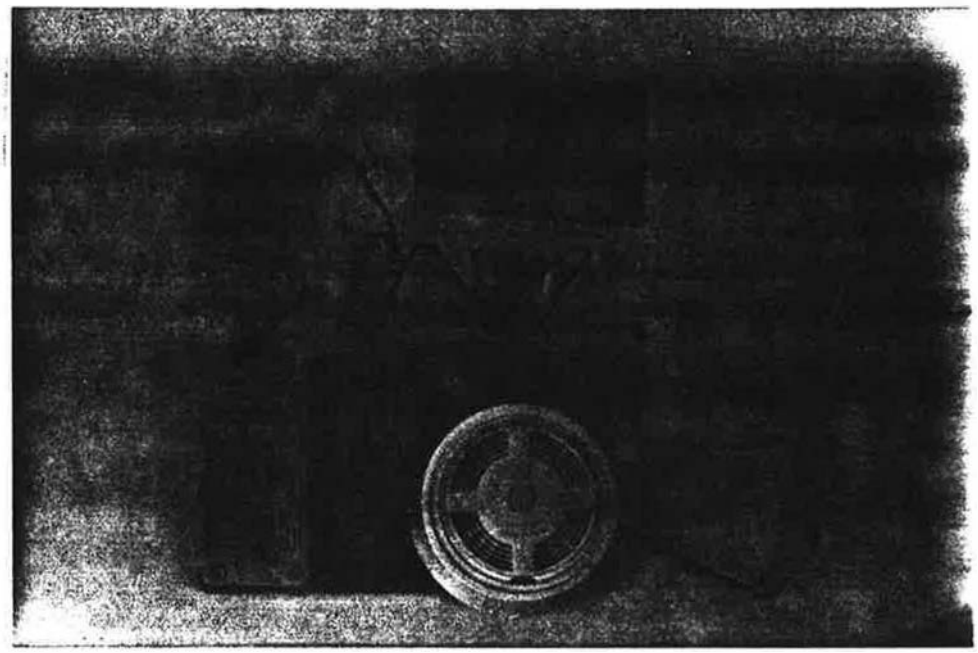
Tests were conducted in the field and lab to determine the response time of the smoke and CO detectors, and to evaluate alternative products. The Canadian-made Dicon smoke detector was found to be as sensitive (and less expensive) as the alternatives commercially available. It was not possible to test a combined ionization/photo-electric detector since these brands were no longer available locally. In any case, the Dicon detector was found very reliable, consistently detecting spills within 10 to 15 seconds. When measuring response times, the timing was started as soon as the combustion gas was observed to spill out from the lip of the fireplace opening. A smoke pencil was used to enhance the ability to detect flows (while keeping the chemical smoke to one side of the detector, so as to avoid interference).

The Newtech CO detector, developed in Vancouver, and using an improved detection process now under patent application, was tested and compared against CO analyzers and alternative products, such as the CO-Sensor and the Gas Sniffer. The Newtech detectors were found to be as reliable and sensitive for purposes of this research as the alternative products. Newtech has a cycle of 60 seconds, preferable to the 120 second cycle of a CO-Sensor. The 60 second cycle time causes a delay in response of approximately 60 seconds, following exposure of the detectors to concentrations above the detection limit.

Extensive consultations were made with technical staff at Newtech, to determine if the sensitivity of the detectors could be reduced to 10 or 20 ppm of CO, since field data-indicated that spillage in the 20 - 30 ppm range is likely to be common. Unfortunately, the Japanese-made Figaro sensors, used in their detectors, have variable strength outputs. By testing a large number of sensors, it was possible for them to find 24 sensors with sufficient signal to permit calibration in the 40 to 50 ppm range. To make the detectors more sensitive still would have required use of an alternative testing circuit, such as that used by CO-Sensor. Consequently, the CO detectors were standardized at 50 ppm ($\pm$ 10 ppm).

Figure 1

Photograph of the Fireplace Spillage Detector



To permit easy mounting of the detector, a hinged hanging hook was affixed to the back corners, and wire provided for hanging the box from a tack in the wall or mantle, or from tacks at either side of the fireplace chimney.

2.3 Fabrication and Testing

Twenty-four detectors were fabricated according to specification. Care was taken to construct the detectors in a durable fashion to withstand shipping and handling. Care was also taken to make the detectors aesthetically pleasing, at least in a "high-tech" fashion, since householders are always concerned about the appearance of their mantle. A photograph of a sample detector is presented in Figure 4. A list of the parts for each counter is provided in Appendix 2.

After fabrication, each detector was subjected to a test of circuits, and to tests of the response time and accuracy of the CO and smoke detectors. CO testing was accomplished by simply placing the detectors in various plastic bags containing varying concentrations of CO. Concentration of CO in the test bags was increased, very slowly, until the detectors were triggered. The detectors were sensitive to 45 ppm CO $\pm$ 10 ppm. As previously mentioned, the cycle times cause a delay in response. One minute was typical. This delay is partially compensated by a delay in shutting off after CO levels subside. A lag of 35 seconds is typical in shutting off, which results in an accumulated time error (or loss) of about half a minute for each CO spillage event.

The commissioning of circuits included:

- testing each counter operation, in accordance with a standard checklist,
- plugging in the detector for at least 24 hours, and
- retesting all of the circuits.

The detectors were labelled from 1 to 24 by region:

- Winnipeg - 1 to 8;
- Ottawa - 9 to 16; and
- Vancouver - 17 to 24.

2.4 Installation of the Detectors

While the project was intended to start in November, 1986, the installation of detectors took place during the week of December 4 to December 12. The delay was a result of difficulties in obtaining supplies of the miniature mechanical counters.

Installation was conducted by Yuill and Associates in Winnipeg, by Scanada Consultants Inc. in Ottawa, and by Sheltair Scientific Ltd. in Vancouver. Householders in all regions were found to be anxious to receive their detectors, having already received their wood.

The installation was normally a five-part job:

1) Installing the detector above the fireplace, following the instructions provided.

2) Completing an Installation Report Form. The form included recording the readings on detector counters, as well as recording all the data previously collected on houses in the initial survey. A photograph of the installation was also required.

3) Conducting a Venting Systems Test to determine the maximum house depressurization created by competing exhaust devices. The Venting Systems Test was conducted in accordance with the second draft of CGSB 50.71 (Ref. 2).

4) Conducting a fan depressurization test in accordance with CGSB 149.10M (Ref. 3).

A sample of the installation instructions is provided in Appendix 1.

3. RESULTS

3.1 Performance of the Detectors and Householder Participation

In general, the detectors performed as intended in the houses with a couple of exceptions. In one case, the householder noticed the CO counter ticking while a group of people, smoking cigarettes, was standing around the fireplace during an evening party. Fortunately, the householder estimated the extra counts caused by the cigarette smoke, and it was possible to factor out these interferences. However, the sensitivity of CO detectors to high concentrations of cigarette smoke is an inherent disadvantage to using CO detectors for recording fireplace spillage events, and may have influenced other detectors in houses with smokers.

In another case, House No. 14, a householder complained of constant ticking of the CO counter for long periods, for no apparent cause. The detector was removed for several weeks of testing, but was found to be performing properly. Consequently, further investigations were conducted at the house. It was determined that the householder had been regularly idling his car in an enclosed garage, adjacent to the fireplace room. The car exhaust had been drawn into the fireplace room, and, presumably, had triggered the CO detector. Once again, the presence of CO from other sources interfered with the spillage monitoring. In hindsight, it may have been warranted to install a CO alarm in the fireplace room, away from the fireplace, to alert both householders and researchers to the presence of CO from other sources.

Participation by householders was excellent in most cases with all householders diligently recording the number of fires and the duration of each fire. Householders had been requested to record fire operating time to the nearest hour (ie. $\pm$ 30 minutes), but many recorded time to the minute, as well as dates, and any unusual events such as power outages, closing dampers prematurely, or operating the fireplace with doors open. A number of complaints were received about poor quality firewood. The Ottawa and Vancouver contractors hired to supply wood had evidently failed to deliver clear, dry hardwood as promised. In one case, House No. 21, the householder claimed the wood was salty and unsuitable for burning, and

without informing the researchers, decided to curtail use of the fireplace after only five fires. Although the object of providing firewood to householders was to encourage lots of fires, greater effort was needed to ensure high quality wood. Researchers in each region had a difficult time locating large quantities of dry hardwood late in the season.

In three houses (No. 1, 2, and 7), one or two power outages were recorded by the householders. Although octopus plugs had been provided, along with warnings about unplugging the detectors, it was not always possible to avoid a power outage. Fuses were blown (at Christmas time), a cord was accidentally pulled, and utility power was cut off. Adjustments have been made to the data, since a power outage always caused a CO event counter to add one event. In addition, the CO duration counter and the CO and/or smoke duration counter could both be affected if the CO detector happened to be cut off in its warm-up phase. Under worst case conditions the detector could record up to 50 seconds of erroneous CO spillage time, although normally the detector would be warmed up and reliable. To compensate for the possibility of erroneous counts, both the counters have been reduced by 50 seconds for each known case of a power outage.

3.2 Description of Houses and Results of the Tests

An information sheet on each of the 24 houses can be found at the end of this report. Each information sheet includes a photograph of the fireplace, with the detector installed, and conveys a lot of detail on the types of fireplaces and precise locations of the detectors. In addition, the information sheets summarize the physical characteristics of the house and its heating, ventilating, and air conditioning (HVAC) systems. Details include: house age; fireplace and chimney type, location, and height; and the type of exhaust fans. (Most of this information parallels the data collected on the initial 1986 survey.) Information sheets also contain comments about features the house or operation that may influence the venting performance (eg. exceptionally short chimneys, high buildings nearby, use of wet wood).

Table 1
AIR LEAKAGE AND VENTING TEST DATA
OTTAWA

House Number	Air Leakage Characteristics				Venting Systems Test (worst case conditions*)		
					House Depressurization (Pascals)		Spillage Observations
	n	C	ELA (cm^2)	ACH_{50}	Exhaust Fans	Fans Plus Furnace & DHW	
1	0.675	157.2	2986	10.51	2.5	1.25 - 2.5	Furnace - >30 seconds
2	0.811	43.5	1129	23.15	*	*	No spillage observed
3	0.819	20.0	530	2.31	8.7	*	Fireplace - >3 minutes
4	0.757	36.8	845	6.38	1.2	3.7	No spillage observed
5	0.727	29.7	637	3.97	2.5	5.0	Furnace - >3 minutes DHW - >30 seconds
6	0.641	70.5	1238	7.38	1.2	2.5	Fireplace - >30 seconds
7	0.734	55.0	1195	6.01	1.9	3.7	No spillage observed
8	0.740	32.9	726	4.35	6.2	5.0	Fireplace - >3 minutes Furnace - >30 seconds

* Worst case conditions were created by closing the house as tightly as possible, and operating all the "Exhaust Fans." The DHW heater and furnace were then operated, in addition to the exhaust fans, but only in houses where operation of these appliances was convenient.

Table 2
AIR LEAKAGE AND VENTING TEST DATA
WINNIPEG

House Number	Air Leakage Characteristics				Venting Systems Test (worst case conditions*) House Depressurization (Pascals)		Spillage Observations
	n	C	ELA (cm^2)	ACH_{50}	Exhaust Fans	Fans Plus Furnace & DHW	
9	**	**	**	**	5.5	*	No spillage observed
10	0.69	19.8	0.04	1.94	2.0	8.0	Fireplace - >3 minutes Furnace - >3 minutes DHW - >3 minutes
11	0.75	14.2	0.03	1.63	1.5	2.0	Fireplace - >30 seconds Furnace - <30 seconds DHW - >3 minutes
12	0.58	33	0.052	1.65	2.0	3.0	No spillage observed
13	0.67	28.7	0.056	2.87	3.0	*	Fireplace - >30 seconds open house - >30 seconds
14	0.62	40.2	0.068	1.67	**	**	**

* Worst case conditions were created by closing the house as tightly as possible, and operating all the "Exhaust Fans." The DHW heater and furnace were then operated, in addition to the exhaust fans, but only in houses where operation of these appliances was convenient.

** Data unavailable due to co-operation problems with householders.

Table 2: Air Leakage and Venting Test Data - Winnipeg (continued)

House Number	Air Leakage Characteristics				Venting Systems Test (worst case conditions*) House Depressurization (Pascals)		Spillage Observations
	n	C	ELA (cm^2)	ACH_{50}	Exhaust Fans	Fans Plus Furnace & DHW	
15	0.71	17.8	0.037	2.07	1.0	*	Furnace - >30 seconds open house - >30 seconds
16	0.52	38.2	0.053	2.07	5.0	*	Furnace - >30 seconds

* Worst case conditions were created by closing the house as tightly as possible, and operating all the "Exhaust Fans." The DHW heater and furnace were then operated, in addition to the exhaust fans, but only in houses where operation of these appliances was convenient.

Table 3
AIR LEAKAGE AND VENTING TEST DATA
VANCOUVER

House Number	Air Leakage Characteristics				Venting Systems Test (worst case conditions*)		
					House Depressurization (Pascals)		Spillage Observations
	n	C	ELA (cm^2)	ACH_{50}	Exhaust Fans	Fans Plus Furnace & DHW	
17	0.698	102.5	2089	9.35	3.0	3.0	Furnace - tight house - <30 seconds
18	0.817	60.2	1616	8.91	*	0.5	<30 seconds
19	0.660	150.9	2818	15.14	0	0	<30 seconds
20	0.752	32.0	738	8.86	Data unavailable		<30 seconds
21	0.788	73.4	1852	8.00	1.0	1.0	<30 seconds
22	0.726	44.7	965	6.49	4.0	5.5	<30 seconds
23	0.847	49.2	1410	9.94	3.0	3.5	<30 seconds
24	0.828	59.0	1613	15.03	Data unavailable		<30 seconds

* Worst case conditions were created by closing the house as tightly as possible, and operating all the "Exhaust Fans." The DHW heater and furnace were then operated, in addition to the exhaust fans, but only in houses where operation of these appliances was convenient.

The 24 houses include a range of styles and ages, from pre-1900 to post-1975. Newer houses predominate, with 71 percent of the sample built since 1960. Twelve fireplaces are open masonry units, and the remaining twelve are fitted with conventional varieties of glass doors. (Many householders will operate fireplaces with the glass doors open, so the presence of doors does not necessarily mean a different type of performance is expected.)

In all but one case, the fireplace spillage detectors were mounted directly above the centre of the fireplace, 300 to 450 mm above the upper edge of the fireplace opening.

Tables 1, 2, and 3 present data from the air leakage tests and venting systems tests for houses in each of the three regions (Ottawa, Winnipeg, and Vancouver respectively).

The average ELA for the Vancouver houses is 1637 cm^2. All of the Vancouver houses could be classified as very leaky (by comparison with average existing Canadian houses). The average ELA for the Ottawa houses is 1160 cm^2, closer to an average for all Canadian houses. Two of the Ottawa houses (No. 3 and No. 5) are much tighter than average for new Canadian houses. Winnipeg houses are considerably tighter than the Ottawa houses in almost all cases.

The "worst case" house depressurization was measured while simultaneously operating all household exhaust fans, and again while operating both the fans and the furnace and water heater. Three of the Ottawa houses (No. 3, 5, and 8) exceeded the House Depressurization Limits (HDL) (Ref. 1). These same houses were also observed to suffer from prolonged (>30 seconds) start-up spillage from both furnaces and fireplaces under worst case conditions. House No. 1 also experienced excess spillage from the furnace at start-up (although the house depressurization was only 2.5 Pascals).

Two of the Winnipeg houses (No. 10 and No. 16) exceeded the HDL, and also experienced excess spillage while under observation. The fireplace in House No. 13 spilled due to 3 Pascals of house depressurization caused by exhaust

fans. In House No. 11, both the fireplace and water heater spilled excessively, despite only 1.5 to 2 Pascals of depressurization under worst case conditions.

One of the Vancouver houses exceeded the HDL (House No. 20 at 4 Pascals with fans operating, and 5.5 Pascals with fans and furnace). Another two houses had house depressurization in the 3.0 Pascal range. However, none of these Vancouver houses experienced excess spillage while under observation.

3.3 Spillage Events Recorded By Detectors

The data from the spillage detectors has been summarized in Tables 4, 5, and 6. Each of these tables lists the number of fires burned for each house, and the number and duration of different types of spillage events.

The monitoring period lasted approximately 90 days for each house (± 5 days). During this period householders used their fireplaces an average of 24 times. In one case, a householder had only five (5) fires, but another householder had 73 fires, and another 38 fires. Altogether the householders burned 563 fires, for a total burn time of 2,435 hours. The average duration of a single fire was 4 hours and 20 minutes.

Smoke Spillage Events

Table 4 is a summary of the spillage events recorded by the smoke detector. House No. 3, containing a pre-fab metal fireplace with glass doors, recorded no smoke spillage events. House No. 22, a masonry fireplace with glass doors, recorded only one (1) spillage event (although in this case the detector had to be located off-centre, and may have missed any minor spillage events). All other houses experienced a number of smoke spillage events, in most cases surprisingly high. House No. 17 had an incredible 2084 spillage events, and other houses recorded from 248 to 653 event counts. To confirm these high counts all of the data was verified by re-checking the

Table 4
SPILLAGE FREQUENCY AND DURATION FOR SMOKE ONLY

House Number	Monitoring Period (days)	Number of Fires	Events	Total Duration (minutes)	Average Spill Length (min)
1	91	13	106	37	0.35
2	90	17	57	13	0.23
3	90	18	0	0	0
4	87	30	154	85.3	0.55
5	88	73	26	7.5	0.29
6	89	27	573	105.5	0.18
7	85	25	35	4.5	0.13
8	89	26	653	108.3	0.17
9	87	29	253	33.8	0.13
10	82	21	90	20.5	0.23
11	87	19	72	9.2	0.13
12	83	38	0	0	0
13	87	24	30	6.7	0.22
14	79	9	4	0.2	0.04
15	85	24	28	3.7	0.13
16	89	17	189	18	0.10
17	94	16	2084	400.2	0.19
18	100	28	89	14.8	0.05
19	100	21	7	1.5	0.21
20	88	23	134	14.8	0.11
21	90	6	46	1.7	0.04
22	90	11	1	1.5	1.5
23	93	25	248	49.8	0.20
24	88	24	287	37	0.13

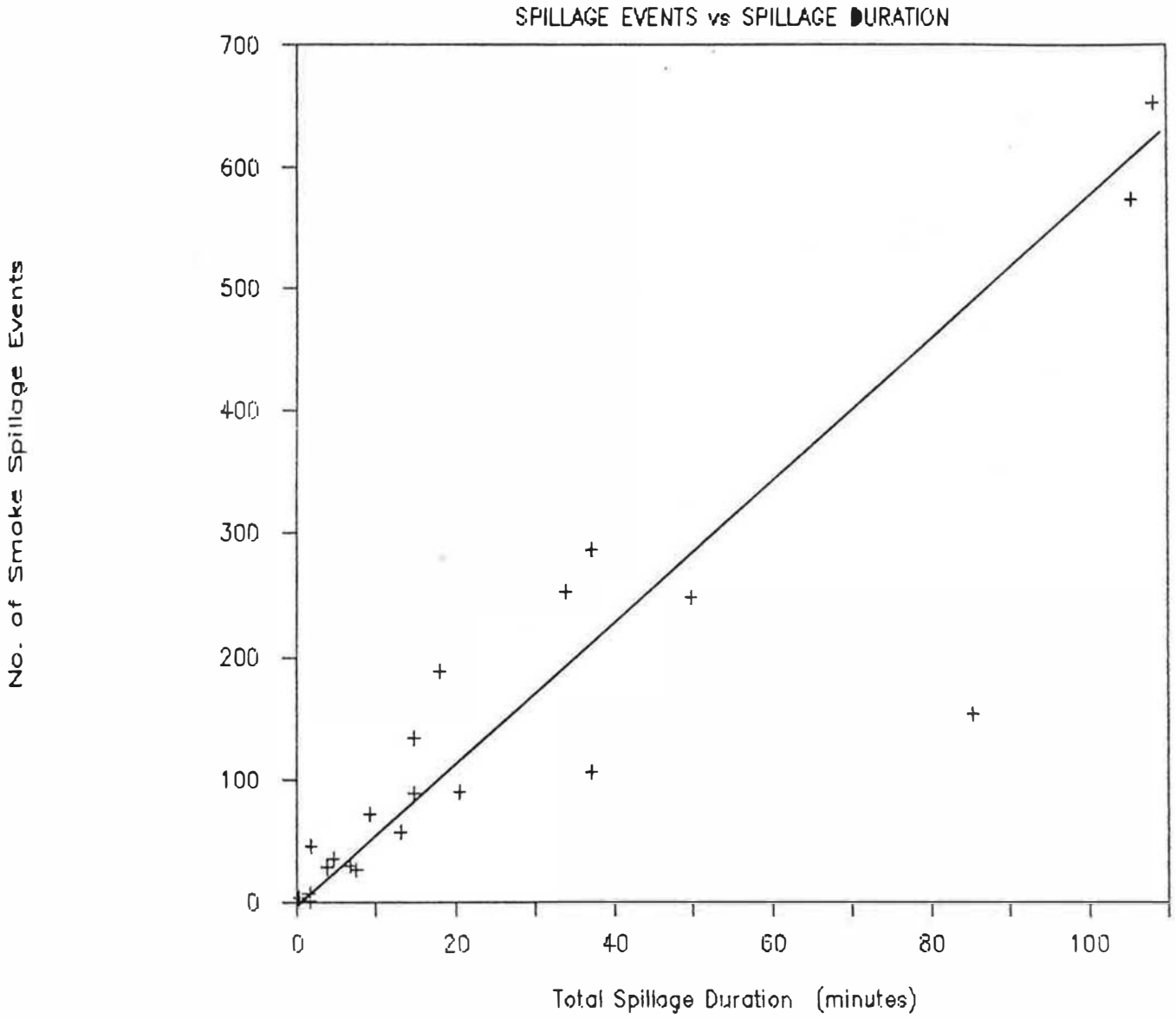


FIGURE 1
SMOKE SPILLAGE EVENT FREQUENCY IN RELATION
TO TOTAL SPILLAGE TIME FOR EACH FIREPLACE

counters, recording forms, and other original data. As well, tests were conducted on the detectors and batteries to confirm their operating condition. The data appeared to be free of errors, as did the equipment. Thus the only explanation is that many of the fireplaces had experienced continuous puffing or short-term intermittent spillage during operation. This explanation is supported by the appearance of some of the detectors which were noticeably stained by smoke and in several cases actually showed creosote build-up on the metal housing.

The event frequency increases in proportion to the duration of smoke spillage for each fireplace. Consequently, the average length of a smoke spillage event is fairly consistent from house to house, averaging 0.2 minutes (or 12 seconds). The correlation between events and duration is illustrated in Figure 1, (correlation coefficient = 0.898).

Rapid on/off cycling of smoke detectors during a single spillage event is unlikely, since the smoke detectors were observed to have a lag time of approximately 10 seconds. During field tests on prototype detectors, rapid cycling did not occur, even when exposed to continuous spillage of gases at very low volumes. It is more likely that slight variations in rate of burn, wind conditions at the chimney top, and flame location in the firebox produce variations in chimney draft, creating a series of discrete spillage events at times when venting conditions are marginal.

House No. 4 stands out from the rest with a longer spillage length, averaging 0.55 minutes (33 seconds) per event. The heavy staining above this open fireplace (see House Description sheets) suggests a propensity to longer spillage events, and householders claim that wood smoke odours are common.

Householders in House No. 8 (where smoke spillage events totaled 653) noticed frequent clicking of the counters on occasions when "logs rolled to front of the firebox" or "when the damper was closed too soon."

The large number of short-term smoke spillage events in these houses raises the possibility that significant quantities of combustion products are entering houses because of wood burning in fireplaces. This entry rate is gradual, allowing for mixing and dilution with the total volume of household air, and avoiding concentrations of smoke sufficient to alert or annoy occupants.

A number of the houses in the sample show significant counts of smoke spillage (Houses No. 1, 4, 6, 8, 9 10, 16, 17, 20, 23, and 24). These high spillage houses include a mix of leaky and tight houses, high and low house depressurization values, fireplaces with and without glass doors, and with metal and masonry enclosures. No single variable seems closely associated with spillage occurrences. It is likely that the design and condition of the fireplace chimney, and the operating techniques of the householders, are the major factors in influencing spillage, although insufficient data exists to evaluate these variables.

Carbon Monoxide Spillage Events

Table 5 summarizes the spillage events and durations recorded by the carbon monoxide detector. All houses had at least one (1) CO spill recorded, but the number of events in each house is much smaller than for smoke spillage. The average number of events is 26 per house, with the highest houses at 125 events (House No. 24), and 109 events (House No. 17). The duration of the CO spills is much higher than for smoke, with an average spill length of 2.7 minutes.

Spills shorter than 10 seconds can not be recorded by detectors. This explains why House No. 19 has 9 events with no duration - all the spills must have been shorter than 10 seconds.

The lower number of spill events for the CO detector, compared to the smoke spillage detector, may reflect the 50 ppm sensitivity limit for the detectors. (Many of the fireplace spills evaluated during testing of

Table 5
SPILLAGE FREQUENCY AND DURATION FOR CO ONLY

House Number	Monitoring Period (days)	Number of Fires	Events	Total Duration (minutes)	Average Spill Length (min)
1	91	13	14	18.7	1.34
2	90	17	3	7.2	2.40
3	90	18	9	0	0
4	87	30	4	3	0.75
5	88	73	40	9.3	0.23
6	89	27	37	78	2.11
7	85	25	13	2.4	0.19
8	89	26	38	120	3.16
9	87	29	48	6.7	0.14
10	82	21	8	13.2	1.65
11	87	19	19	33.8	1.78
12	83	38	41	139.2	3.39
13	87	24	9	6	0.67
14	79	9	17	436.4	25.67
15	85	24	6	4.7	0.78
16	89	17	15	31.5	2.1
17	94	16	109	334.3	3.07
18	100	28	9	9.3	1.04
19	100	21	13	47.7	3.67
20	88	23	17	42.2	2.48
21	90	5	9	30.2	3.35
22	90	11	7	12.3	1.76
23	93	25	1	1	1
24	88	24	125	165.7	1.33

prototype detectors were seen to be in the 20 to 50 ppm range, too low to be detected.)

Fewer CO spills can also be explained by the longer lag time (30 to 60 seconds) for the detector to operate. The many short-term spills recorded by the smoke detectors would not be of sufficient length to trigger the CO detector.

Because of these factors, the lag time of 30 to 60 seconds, and the inability to record spills of less than 10 seconds in duration, it is certain that the duration of spillage recorded by the detectors will be less than that which actually occurred. Spillage duration for spills greater than 50 ppm CO could be as much as twice the recorded spillage. The duration for spills less than 50 ppm CO can not be estimated from the data.

As was the case with the smoke detectors, a good correlation exists between number of events and total spillage duration.

Several houses with high smoke spillage events (House No. 4, 10, and 23) did not record high quantities of CO spillage. These houses emphasize the value of a dual detector system.

Combined CO and Smoke Spillage Events

Table 6 presents a survey of spillage events and duration recorded by both the CO detector and the smoke detector. The events recorded by both detectors have been summed (although in many cases, the detectors will have recorded the same spillage event). The total spillage duration is a record of the time when either CO or smoke was spilling (or both together) and is thus an accurate reflection of the total spillage duration - regardless of composition.

Table 6
SPILLAGE FREQUENCY AND DURATION FOR SMOKE AND CO

House Number	Monitoring Period (days)	Number of Fires	Events	Total Duration (minutes)	Average Spill Length (min)
1	91	13	120	55.7	0.46
2	90	17	60	20.2	0.34
3	90	18	9	0.2	0.02
4	87	30	158	88.3	0.56
5	88	73	66	16.8	0.26
6	89	27	610	183.5	0.30
7	85	25	48	6.7	0.14
8	89	26	691	228.3	0.33
9	87	29	254	34.8	0.14
10	82	21	98	33.7	0.34
11	87	19	91	43	0.47
12	83	38	41	139.2	3.39
13	87	24	39	12.7	0.33
14	79	9	21	436.5	20.79
15	85	24	34	5	0.15
16	89	17	204	126.7	0.62
17	94	16	2193	734.5	0.34
18	100	28	98	14.2	0.15
19	100	21	20	49.2	2.46
20	88	23	151	57	0.38
21	90	5	55	31.8	0.58
22	90	11	8	13.8	1.73
23	93	25	249	50.8	0.20
24	88	24	412	202.7	0.49

Table 7
SPILLAGE TIME AS A PERCENTAGE OF BURN TIME

House Number	Total Minutes of Burn	Total Spillage Duration (minutes)	Spillage Time as a Percentage of Burn Time
1	4,050	55.7	1.38
2	5,940	20.2	0.34
3	6,240	0.2	0.003
4	9,720	88.3	0.91
5	20,280	16.8	0.08
6	9,000	183.5	2.04
7	6,240	6.7	0.11
8	6,180	228.3	3.69
9	1,368	34.8	2.54
10	3,960	33.7	0.85
11	6,960	43	0.62
12	9,060	139.2	1.54
13	9,120	12.7	0.14
14	2,400	436.5	18.19
15	7,020	5	0.07
16	3,240	126.7	3.91
17	5,100	734.5	14.40
18	9,060	14.2	0.16
19	5,280	49.2	0.93
20	8,100	57	0.70
21	1,080	31.8	2.94
22	5,760	13.8	0.24
23	6,000	50.8	0.85
24	6,540	202.7	3.10

No attempt has been made to account for interferences which may have caused CO recordings unrelated to fireplace spillage, although it is known that in at least one case (House No. 14), the CO detector responded to combustion pollutants from other sources. More data on occupants smoking habits would be useful for future studies, especially for houses with frequent CO spillage events.

Table 7 compares the total minutes of burn for all fires in each house (as recorded by householders) with the total spillage duration time. Spillage time for each fireplace is presented as a percentage of the total burn time. On average, the 24 fireplaces spilled for 2.5 percent of their operating time. Spillage time percentages ranged from 0.07 percent to 3.91 percent, for all but two houses in the sample.

The two houses were House No. 14, with a spillage-to-burn rate of 18.19 percent, and House No. 17, with a rate of 14.4 percent. With these two anomalous houses removed from the sample, the average spillage time for fireplaces amounts to 1.2 percent of their operating time.

The high rate of spillage in House No. 14 has been explained previously, and can be attributed to interference by exhaust fumes from a car idling in an adjacent, enclosed garage. It is suspected that House No. 17 experienced extraordinarily high spillage rates because of down winds on the chimney. The installer noted that the house was dwarfed by neighboring trees, and that the fireplace chimney was only 3 meters in height.

4. CONCLUSIONS

The use of smoke detectors and carbon monoxide detectors for monitoring combustion gas spillage from 24 conventional fireplaces has indicated that spillage is a frequent event for almost all types of fireplaces. The duration of the spillage events is short, especially for smokey spills.

With allowance made for anomalous houses, fireplaces were found to spill on average, 1.2 percent of their operating time.

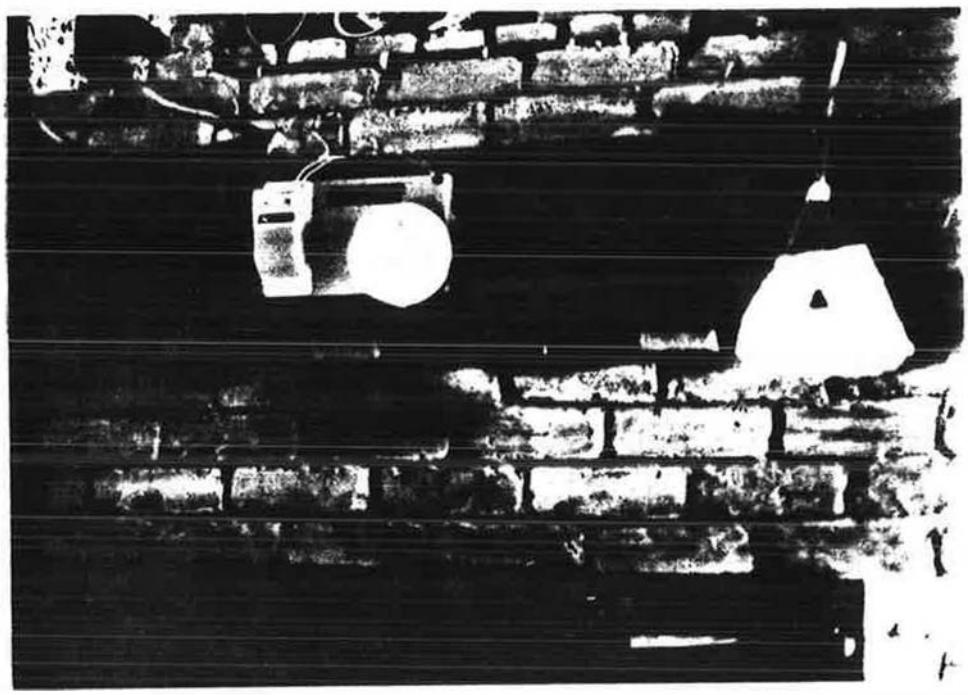
The average duration of spillage events recorded by the ionization smoke detector was 12 seconds.

The average duration of spillage events recorded by the CO detector (>50 ppm) was 2.7 minutes.

No specific features of the fireplaces or houses appear to correlate with a propensity towards spillage events, and it is suspected that the chimney design and fireplace operation are significant variables.

HOUSE DESCRIPTION

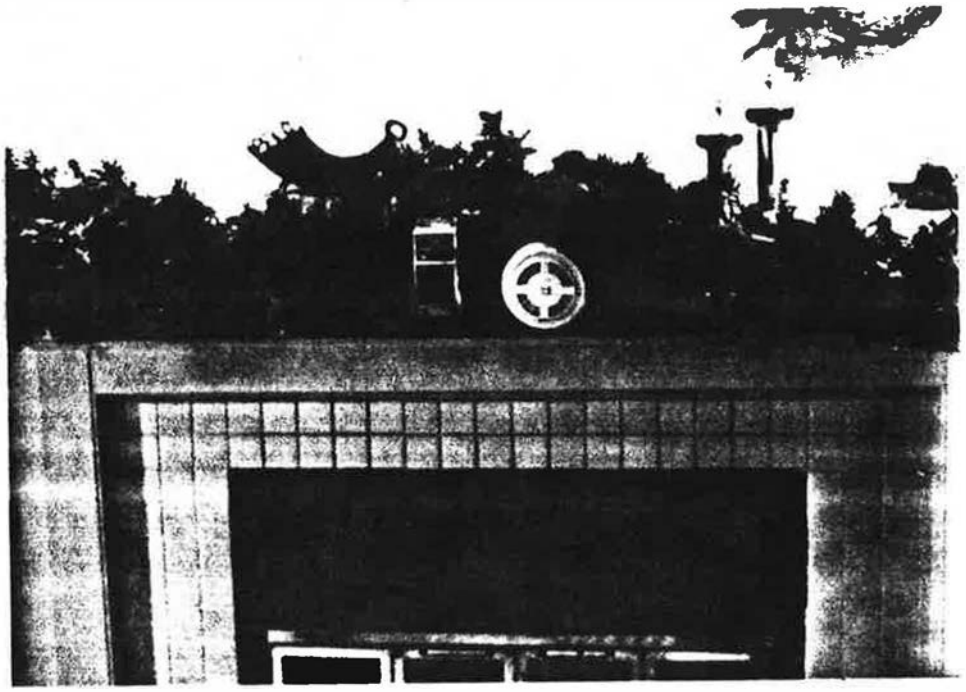
Counter Number: 1
House Location: MacLaren Street, Ottawa, Ontario



- Basement: Small portion with full-height basement, remainder is crawl space or slab on grade
- Stories: 2
- Construction date: Pre 1900
- Furnace: Gas-fired, without flue damper
- DHW: N/A
- Furnace Location: Open basement
- Furnace chimney on outside wall: Yes
- DHW & Furnace share chimney: N/A
- Outdoor portion of chimney is: Brick and metal liner
- Approximate age of furnace: 5 to 10 years
- Converted from oil heating to gas: Yes (new furnace)
- Furnace serviced: More than 3 years ago
- Type of fireplace: Brick with doors
- Notice aroma of wood smoke during or after a fire: Rare
- Exhaust fans: 3 (Bathroom exhaust - taped in winter, stove-top barbecue, and clothes dryer - not used in winter)

HOUSE DESCRIPTION

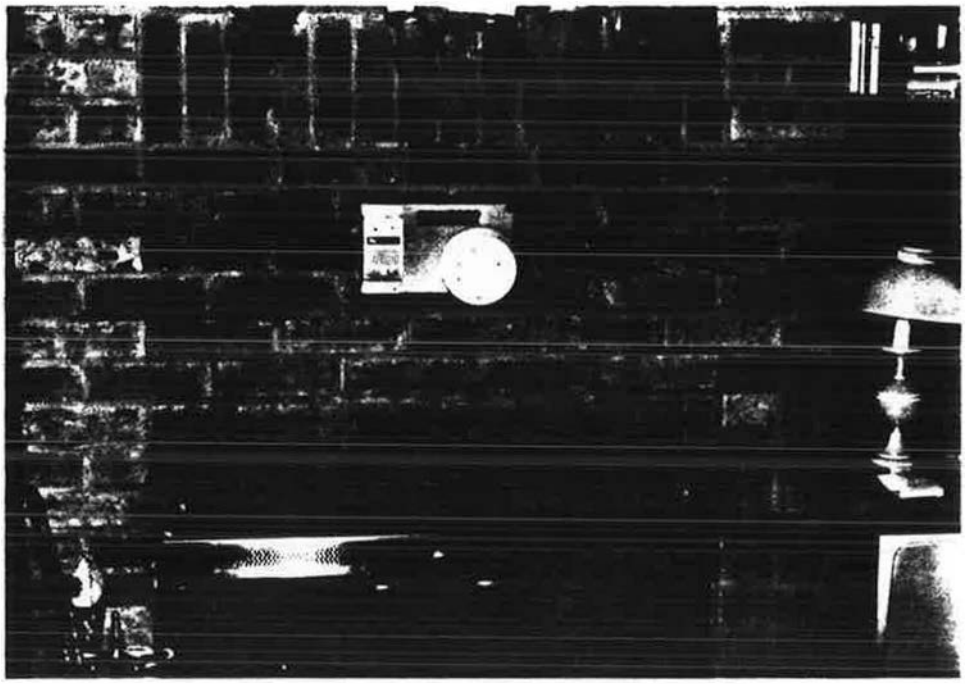
Counter Number: 2
House Location: First Avenue, Ottawa, Ontario



- Basement: Full
- Stories: 2 1/2
- Construction date: 1900 - 1945
- Furnace: Gas-fired
- DHW: N/A
- Furnace Location: Open basement
- Furnace chimney on outside wall: Yes
- DHW & Furnace share chimney: No
- Outdoor portion of chimney is: Brick (or masonry)
- Approximate age of furnace: More than 20 years
- Converted from oil heating to gas: Yes (old boiler converted to gas)
- Furnace serviced: 1 to 2 years ago
- Type of fireplace: Metal with doors
- Notice aroma of wood smoke during or after a fire: Common
- Exhaust fans: 1 (clothes dryer)

HOUSE DESCRIPTION

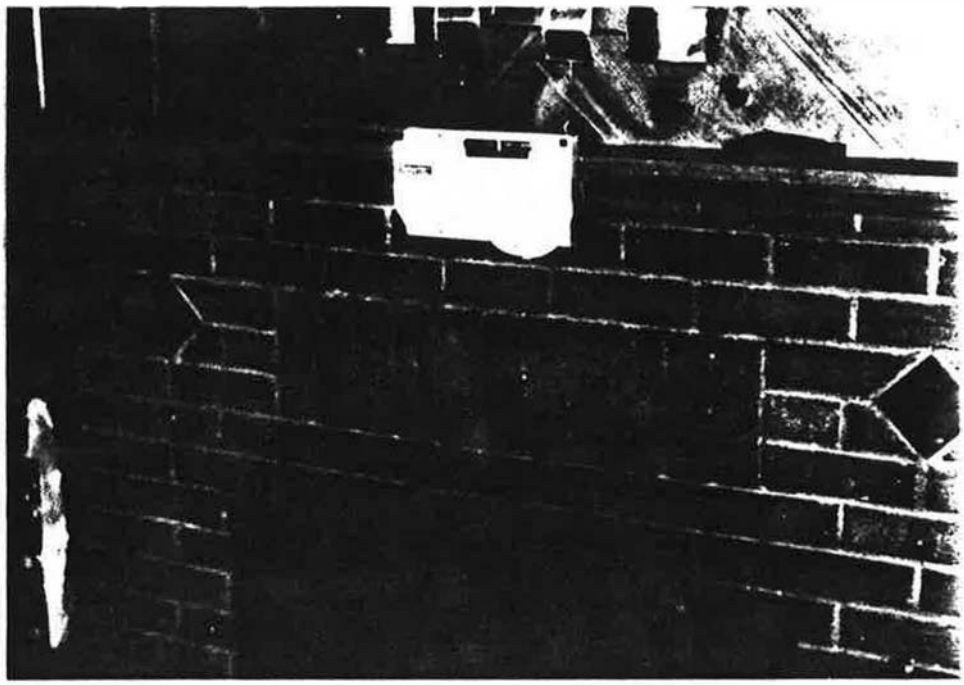
Counter Number: 3
House Location: Island Park, Ottawa, Ontario



- Basement: Full
- Stories: 2
- Construction date: Post 1975 (5 years old)
- Furnace: Electric
- DHW: Electric
- Furnace Location: N/A
- Furnace chimney on outside wall: N/A
- DHW & Furnace share chimney: N/A
- Outdoor portion of chimney is: N/A
- Approximate age of furnace: N/A
- Converted from oil heating to gas: No
- Furnace serviced: N/A
- Type of fireplace: Metal with doors
- Notice aroma of wood smoke during or after a fire: Rare
- Exhaust fans: 4 (bathroom exhaust, stove-top barbecue, clothes dryer, and vacuum)

HOUSE DESCRIPTION

Counter Number: 4
House Location: Highland, Ottawa, Ontario



- Basement: Full
- Stories: 2
- Construction date: 1945 - 1960
- Furnace: N/A
- DHW: N/A
- Furnace Location: Furnace room in basement
- Furnace chimney on outside wall: Yes
- DHW & Furnace share chimney: N/A
- Outdoor portion of chimney is: Brick (or masonry)
- Approximate age of furnace: 10 to 20 years
- Converted from oil heating to gas: No
- Furnace serviced: Less than a year ago
- Type of fireplace: Open brick
- Notice aroma of wood smoke during or after a fire: Common
- Exhaust fans: 3 (Kitchen range hood, bathroom exhaust, and clothes dryer)

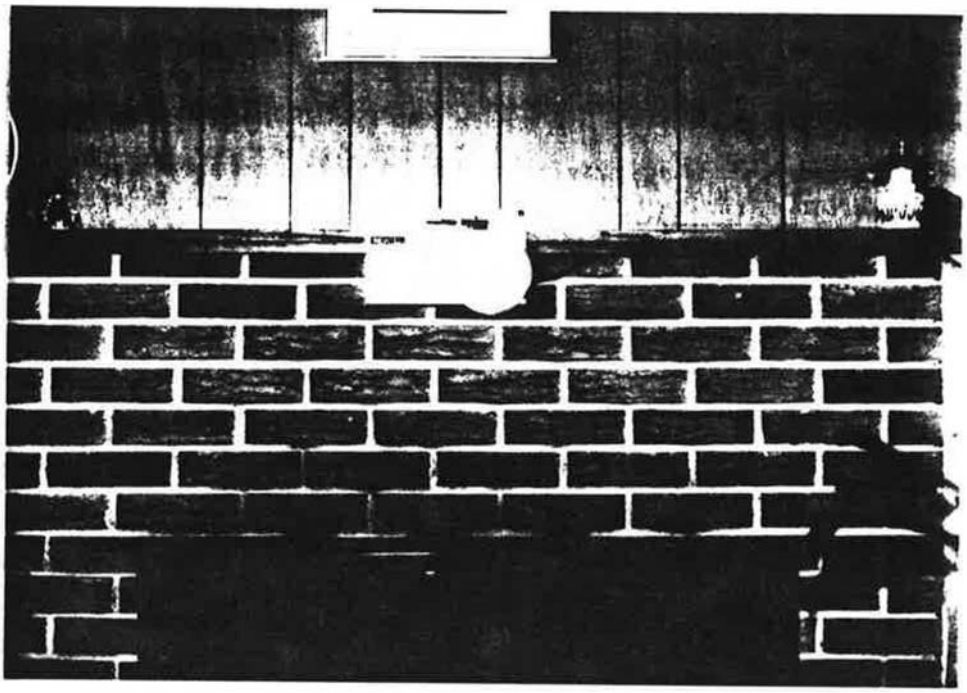
HOUSE DESCRIPTION

Counter Number: 5
House Location: Biscayne Crescent, Nepean, Ontario

- Basement: Full
- Stories: 4 level split
- Construction date: 1970
- Furnace: Oil-fired
- DHW: Oil-fired
- Furnace Location: Open to half of basement
- Furnace chimney on outside wall: Yes
- DHW & Furnace share chimney: Yes
- Outdoor portion of chimney is: Brick (or masonry)
- Approximate age of furnace: 10 to 20 years
- Converted from oil heating to gas: No
- Furnace serviced: 1 to 2 years ago
- Type of fireplace: Open metal
- Notice aroma of wood smoke during or after a fire: Rare (only when starting with paper)
- Exhaust fans: 2 (Kitchen range hood and clothes dryer)

HOUSE DESCRIPTION

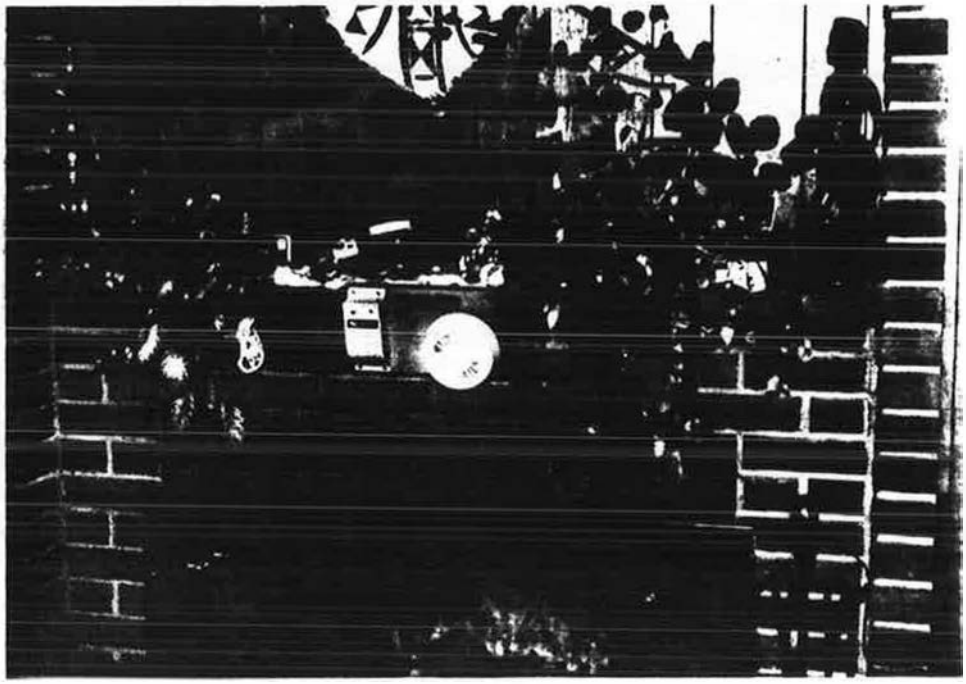
Counter Number: 6
House Location: Bowhill Drive, Nepean, Ontario



- Basement: Full
- Stories: 2
- Construction date: 1960 - 1975 (approx. 12 years old)
- Furnace: Gas-fired
- DHW: Gas-fired
- Furnace Location: Open basement
- Furnace chimney on outside wall: N/A
- DHW & Furnace share chimney: Yes
- Outdoor portion of chimney is: Brick (or masonry)
- Approximate age of furnace: 10 to 20 years
- Converted from oil heating to gas: No
- Furnace serviced: 1 year ago
- Type of fireplace: Open brick
- Notice aroma of wood smoke during or after a fire: Rare
- Exhaust fans: 3 (Kitchen range hood, bathroom exhaust, and clothes dryer)

HOUSE DESCRIPTION

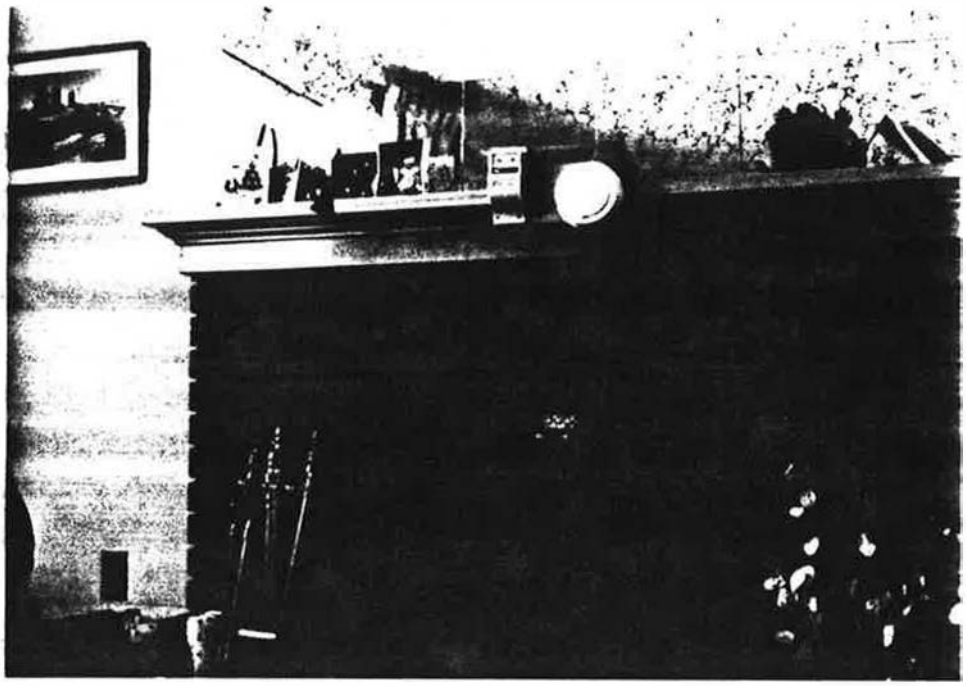
Counter Number: 7
House Location: Withrow, Nepean, Ontario



- Basement: Full
- Stories: 2
- Construction date: 1960 - 1975
- Furnace: Oil-fired
- DHW: N/A
- Furnace Location: Open basement
- Furnace chimney on outside wall: Yes
- DHW & Furnace share chimney: N/A
- Outdoor portion of chimney is: Brick (or masonry)
- Approximate age of furnace: 10 to 20 years
- Converted from oil heating to gas: No
- Furnace serviced: September, 1986
- Type of fireplace: Brick with doors
- Notice aroma of wood smoke during or after a fire: Common
- Exhaust fans: 4 (Kitchen range hood, 2 bathroom exhausts, and clothes dryer)

HOUSE DESCRIPTION

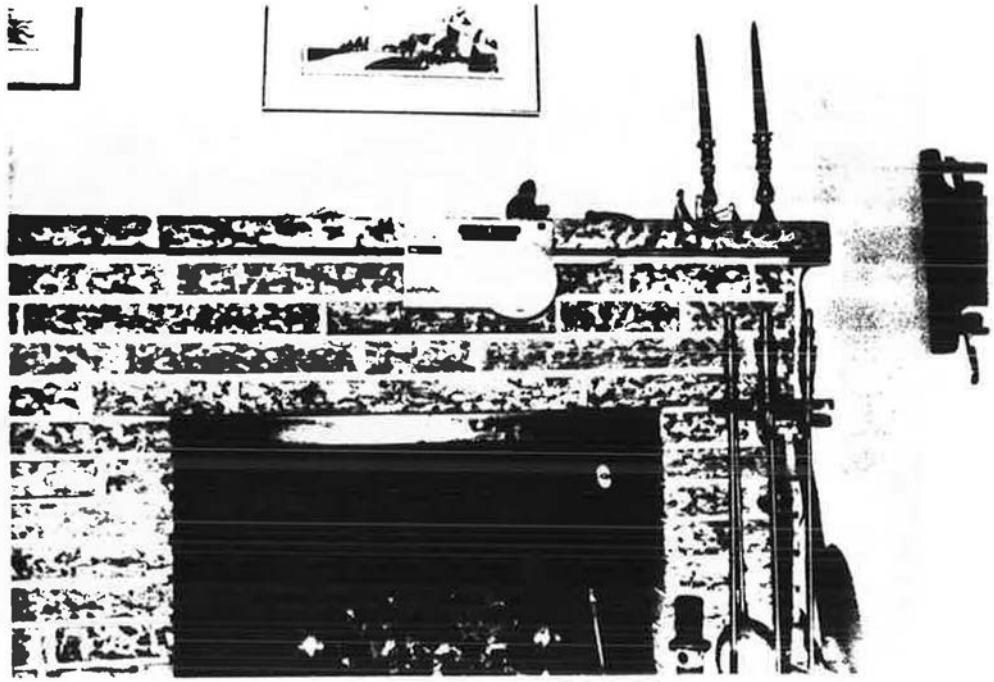
Counter Number: 8
House Location: Ainsley, Ottawa, Ontario



- Basement: Full
- Stories: 1
- Construction date: 1945 - 1960
- Furnace: N/A
- DHW: Electric
- Furnace Location: Open basement
- Furnace chimney on outside wall: Yes
- DHW & Furnace share chimney: No
- Outdoor portion of chimney is: Brick (or masonry)
- Approximate age of furnace: More than 20 years
- Converted from oil heating to gas: No
- Furnace serviced: Less than a year ago
- Type of fireplace: Open brick
- Notice aroma of wood smoke during or after a fire: Rare (but does occur)
- Exhaust fans: 2 (Kitchen range hood and clothes dryer)
- Comments: 4 instances where owners closed damper "too soon" or forgot to open it before starting fire. Householders also noticed clicking when logs rolled out towards front of fire.

HOUSE DESCRIPTION

Counter Number: 9
House Location: Emery Road, Winnipeg, Manitoba



- Basement: Full
- Stories: 2
- Construction date: 1960 - 1975
- Furnace: N/A
- DHW: N/A
- Furnace Location: Furnace room in basement
- Furnace chimney on outside wall: Yes
- DHW & Furnace share chimney: Yes
- Outdoor portion of chimney is: Brick and metal
- Approximate age of furnace: 10 to 20 years
- Converted from oil heating to gas: No
- Furnace serviced: Less than a year ago
- Type of fireplace: Open brick
- Notice aroma of wood smoke during or after a fire: Rare
- Exhaust fans: 4 (Kitchen range hood, 2 bathroom exhausts, and clothes dryer)
- Clicking noticed when burning wet wood.

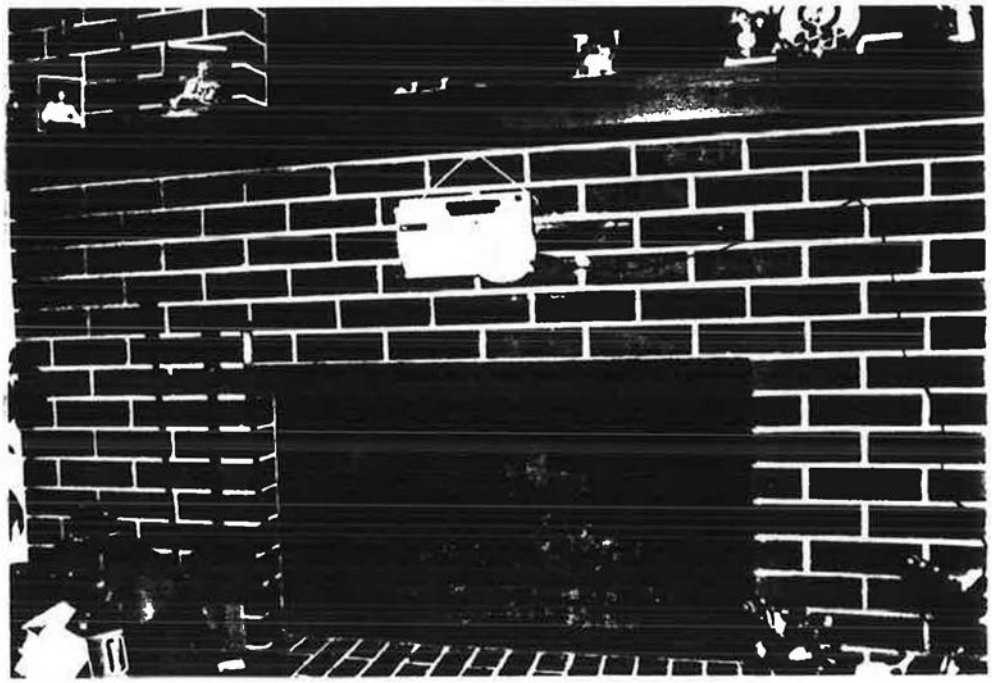
HOUSE DESCRIPTION

Counter Number: 10
House Location: Allandale Road, Winnipeg, Manitoba

- Basement: Crawl space
- Stories: 1 1/2
- Construction date: Post 1975
- Furnace: N/A
- DHW: N/A
- Furnace Location: Open basement
- Furnace chimney on outside wall: Yes
- DHW & Furnace share chimney: Yes
- Outdoor portion of chimney is: Metal
- Approximate age of furnace: Less than 5 years
- Converted from oil heating to gas: No
- Furnace serviced: Less than a year ago
- Type of fireplace: Metal with doors
- Notice aroma of wood smoke during or after a fire: Rare
- Exhaust fans: 5 (3 Bathroom exhausts, clothes dryer, and vacuum)

HOUSE DESCRIPTION

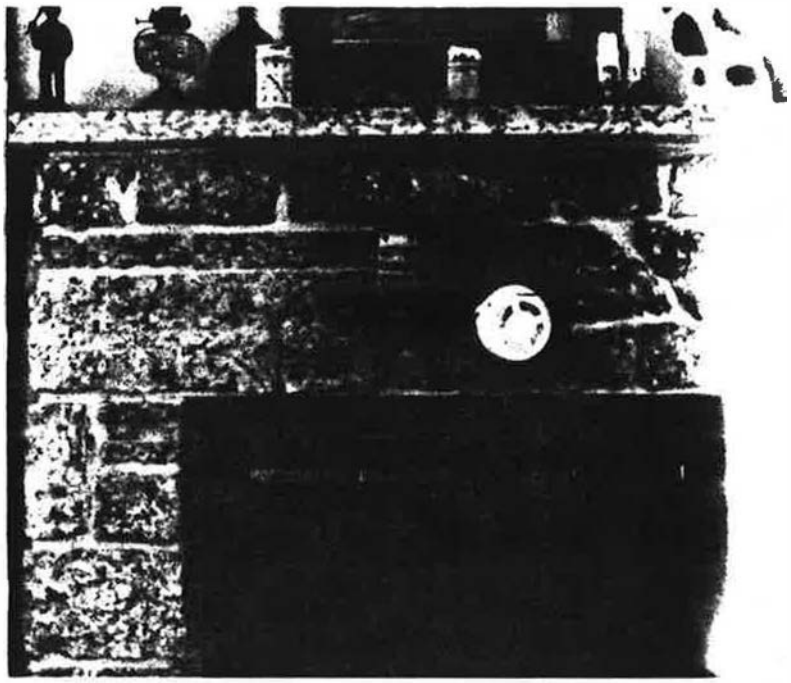
Counter Number: 11
House Location: Augusta Drive, Winnipeg, Manitoba



- Basement: Full
- Stories: 1
- Construction date: Post 1975
- Furnace: N/A
- DHW: N/A
- Furnace Location: Open basement
- Furnace chimney on outside wall: No (but very close)
- DHW & Furnace share chimney: Yes
- Outdoor portion of chimney is: Metal
- Approximate age of furnace: 5 to 10 years
- Converted from oil heating to gas: No
- Furnace serviced: 1 to 2 years ago
- Type of fireplace: Open brick
- Notice aroma of wood smoke during or after a fire: Common
- Exhaust fans: 3 (2 bathroom exhausts and clothes dryer)
- Comments: Householders noticed clicking when turning on exhaust fans.

HOUSE DESCRIPTION

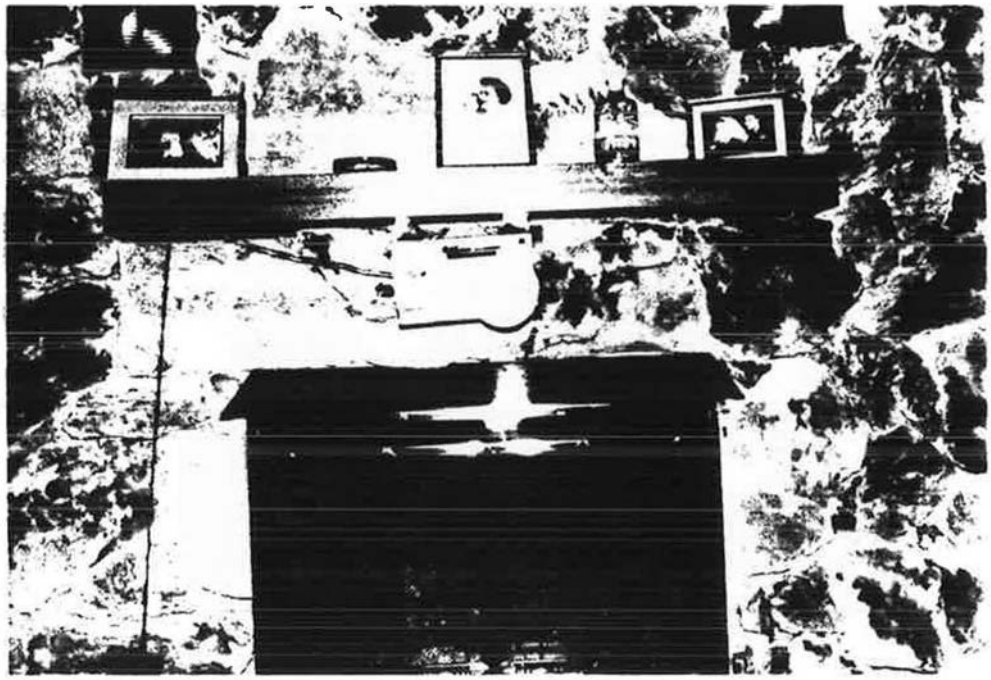
Counter Number: 12
House Location: Allandale Road, Winnipeg, Manitoba



- Basement: Full
- Stories: 1
- Construction date: Post 1975
- Furnace: N/A
- DHW: N/A
- Furnace Location: Open basement
- Furnace chimney on outside wall: Yes
- DHW & Furnace share chimney: Yes
- Outdoor portion of chimney is: Metal
- Approximate age of furnace: Less than 5 years
- Converted from oil heating to gas: No
- Furnace serviced: 2 to 3 years ago
- Type of fireplace: Metal with doors
- Notice aroma of wood smoke during or after a fire: Common (faintly)
- Exhaust fans: 3 (2 Bathroom exhausts and clothes dryer)
- Comments: Housing of smoke detector partially melted on first fire (still works though).

HOUSE DESCRIPTION

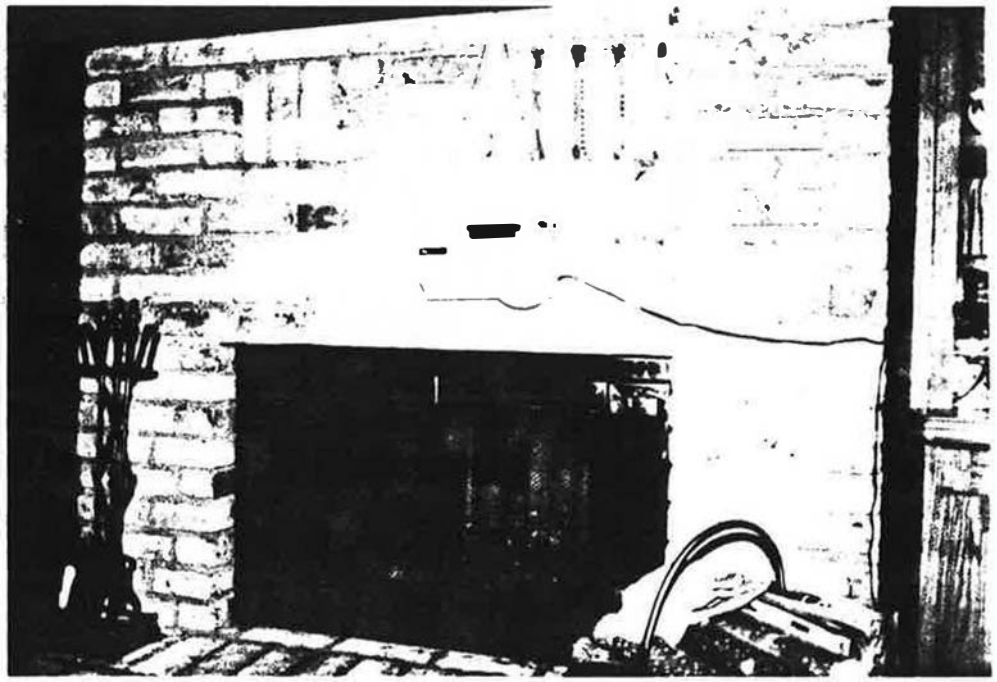
Counter Number: 13
House Location: Rochester Avenue, Winnipeg, Manitoba



- Basement: Full
- Stories: 1
- Construction date: Post 1975
- Furnace: N/A
- DHW: N/A
- Furnace Location: Furnace room in basement
- Furnace chimney on outside wall: Yes
- DHW & Furnace share chimney: Yes
- Outdoor portion of chimney is: Metal
- Approximate age of furnace: 5 to 10 years
- Converted from oil heating to gas: No
- Furnace serviced: Less than a year ago
- Type of fireplace: Metal with doors
- Notice aroma of wood smoke during or after a fire: Rare
- Exhaust fans: 3 (2 Bathroom exhausts and clothes dryer)

HOUSE DESCRIPTION

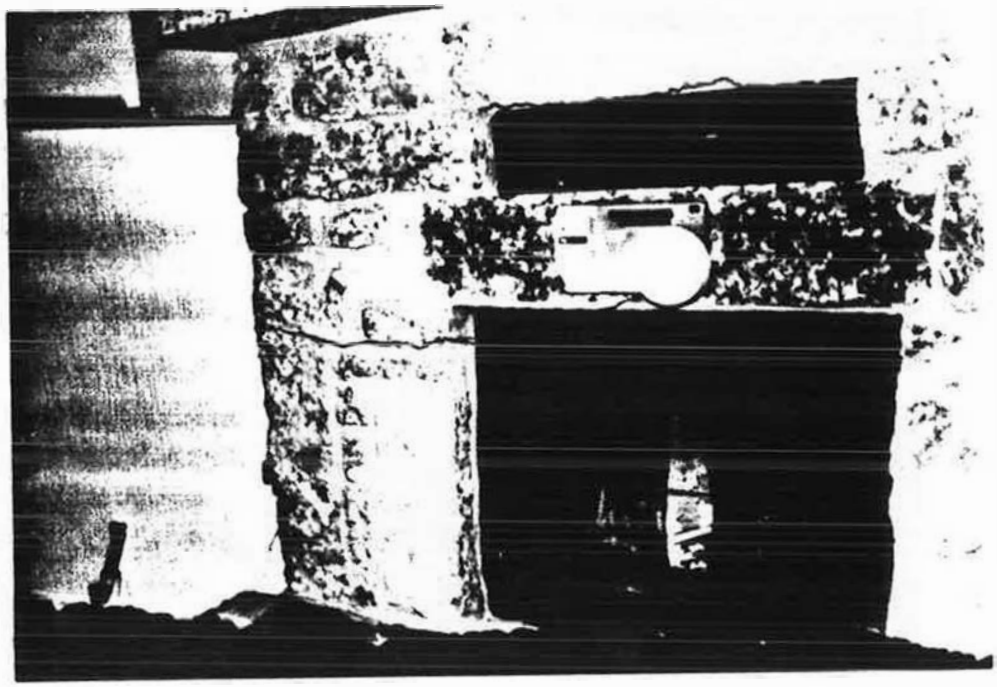
Counter Number: 14
House Location: Park Royal Bay, Winnipeg, Manitoba



- Basement: Full
- Stories: 1 1/2
- Construction date: Post 1975
- Furnace: N/A
- DHW: N/A
- Furnace Location: Furnace room in basement
- Furnace chimney on outside wall: Yes
- DHW & Furnace share chimney: Yes
- Outdoor portion of chimney is: Brick
- Approximate age of furnace: Less than 5 years
- Converted from oil heating to gas: No
- Furnace serviced: Less than a year ago
- Type of fireplace: Metal with doors
- Notice aroma of wood smoke during or after a fire: Rare
- Exhaust fans: 6 (Kitchen range hood, 3 bathroom exhausts, clothes dryer, and vacuum)

HOUSE DESCRIPTION

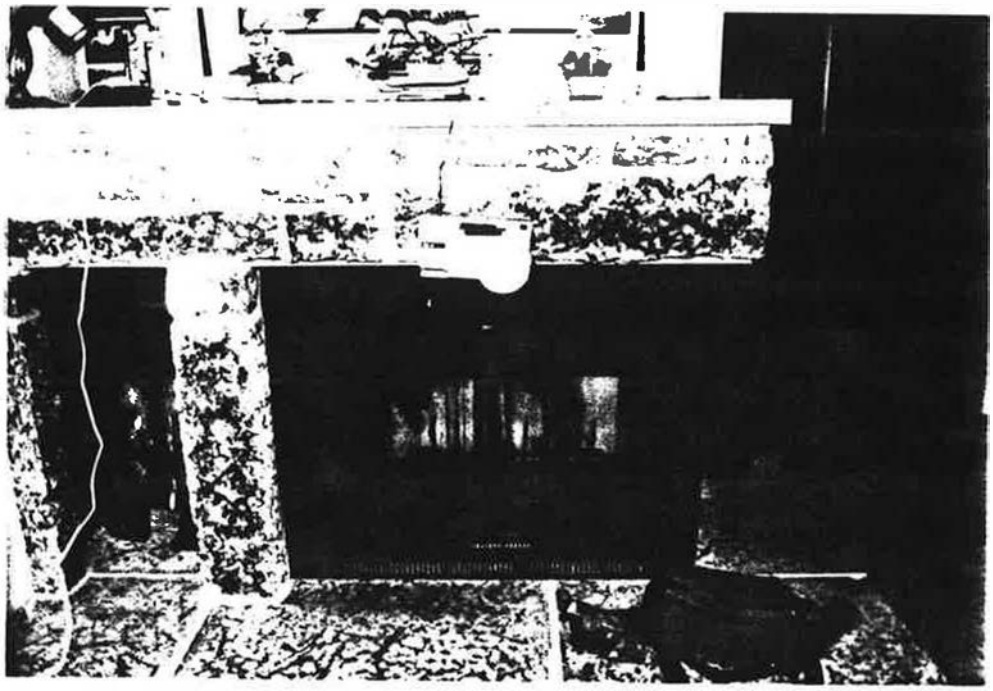
Counter Number: 15
House Location: Allandale Road, Winnipeg, Manitoba



- Basement: Full
- Stories: 1 1/2
- Construction date: Post 1975
- Furnace: N/A
- DHW: N/A
- Furnace Location: Open basement
- Furnace chimney on outside wall: Yes
- DHW & Furnace share chimney: Yes
- Outdoor portion of chimney is: Metal
- Approximate age of furnace: Less than 5 years
- Converted from oil heating to gas: No
- Furnace serviced: 2 to 3 years ago
- Type of fireplace: Open brick
- Notice aroma of wood smoke during or after a fire: Rare
- Exhaust fans: 4 (3 Bathroom exhausts and clothes dryer)

HOUSE DESCRIPTION

Counter Number: 16
House Location: Willowbend, Winnipeg, Manitoba



- Basement: Full
- Stories: 1
- Construction date: Post 1975
- Furnace: N/A
- DHW: N/A
- Furnace Location: Open basement
- Furnace chimney on outside wall: No
- DHW & Furnace share chimney: Yes
- Outdoor portion of chimney is: Metal
- Approximate age of furnace: Less than 5 years
- Converted from oil heating to gas: No
- Furnace serviced: More than 3 years ago
- Type of fireplace: Open brick
- Notice aroma of wood smoke during or after a fire: Rare
- Exhaust fans: 3 (2 Bathroom exhausts and clothes dryer)

HOUSE DESCRIPTION

Counter Number: 17
House Location: Princess Avenue, North Vancouver, B.C.

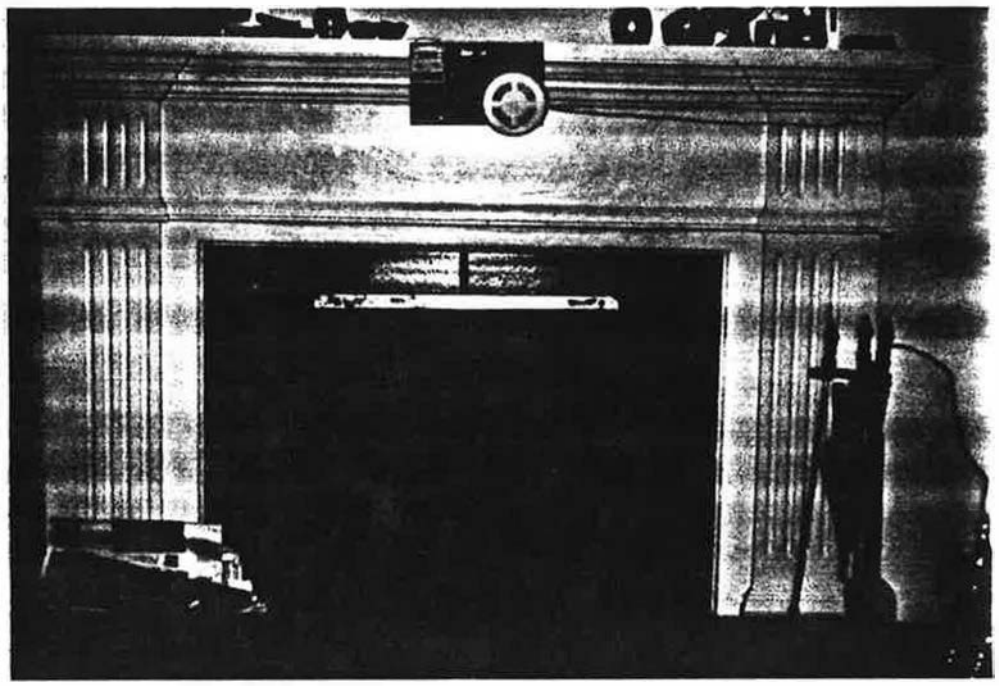
NOTE: The photo for this house was sent with Progress Report 1

- Comments: Dwarfed by neighbouring trees. Chimney height only 3 meters.

- Basement: Full
- Stories: 1
- Construction date: 1960 - 1975
- Furnace: gas-fired without flue damper
- DHW: Gas-fired
- Furnace Location: Furnace room in basement
- Furnace chimney on outside wall: No
- DHW & Furnace share chimney: Yes
- Outdoor portion of chimney is: Metal
- Approximate age of furnace: 10 to 20 years
- Converted from oil heating to gas: No
- Furnace serviced: More than 3 years ago
- Type of fireplace: 1. Open brick, 2. Airtight insert.
- Notice aroma of wood smoke during or after a fire: N/A
- Exhaust fans: 3 (Kitchen range hood, bathroom exhaust, and clothes dryer)

HOUSE DESCRIPTION

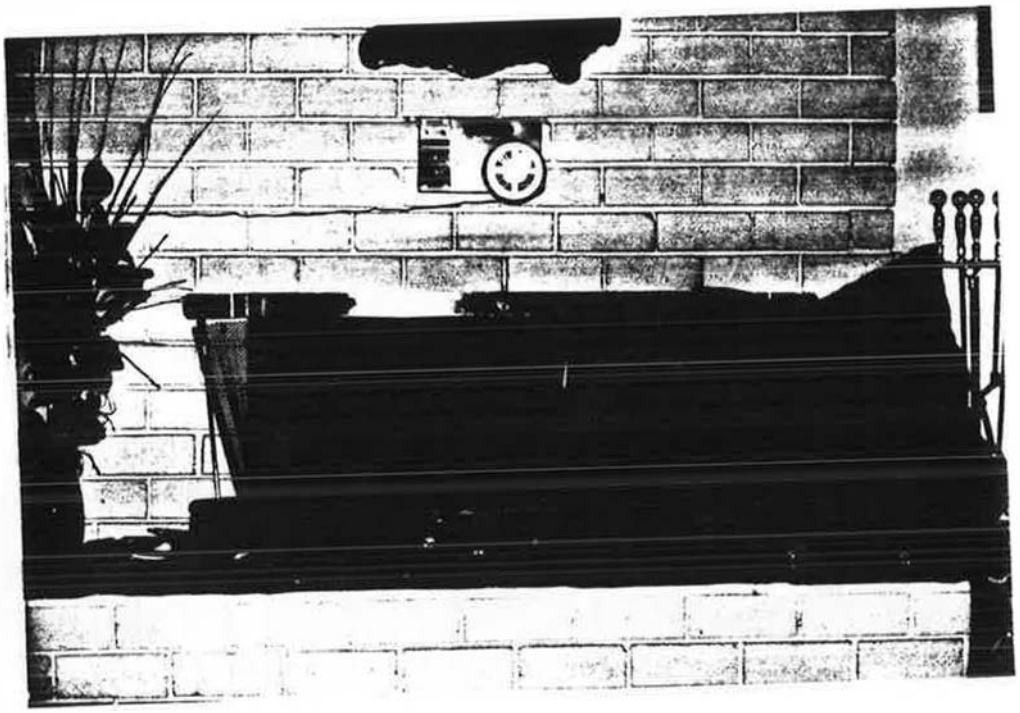
Counter Number: 18
House Location: Ridgewood Drive, North Vancouver, B.C.



- Basement: Crawl space
- Stories: 2
- Construction date: 1900 - 1945
- Furnace: Gas-fired, without flue damper
- DHW: Gas-fired
- Furnace Location: Main floor
- Furnace chimney on outside wall: No
- DHW & Furnace share chimney: Yes
- Outdoor portion of chimney is: Metal
- Approximate age of furnace: Less than 5 years
- Converted from oil heating to gas: Yes
- Furnace serviced: Less than a year ago
- Type of fireplace: Open brick
- Notice aroma of wood smoke during or after a fire: Rare
- Exhaust fans: 1 (clothes dryer)

HOUSE DESCRIPTION

Counter Number: 19
House Location: Palmerston Avenue, West Vancouver, B.C.



- Basement: Crawl space
- Stories: 2
- Construction date: 1945 - 1960
- Furnace: N/A
- DHW: N/A
- Furnace Location: Outdoors
- Furnace chimney on outside wall: Yes
- DHW & Furnace share chimney: Yes
- Outdoor portion of chimney is: Metal
- Approximate age of furnace: 5 to 10 years
- Converted from oil heating to gas: No
- Furnace serviced: Less than a year ago
- Type of fireplace: Open brick
- Notice aroma of wood smoke during or after a fire: Rare
- Exhaust fans: 2 (Bathroom and clothes dryer)

HOUSE DESCRIPTION

Counter Number: 20
House Location: East 5th Street, North Vancouver, B.C.

- Basement: Slab on grade
- Stories: 2
- Construction date: 1960 - 1975
- Furnace: N/A
- DHW: N/A
- Furnace Location: N/A
- Furnace chimney on outside wall: N/A
- DHW & Furnace share chimney: N/A
- Outdoor portion of chimney is: N/A
- Approximate age of furnace: N/A
- Converted from oil heating to gas: N/A
- Furnace serviced: N/A
- Type of fireplace: Open brick
- Notice aroma of wood smoke during or after a fire: Common
- Exhaust fans: 2 (Bathroom exhaust and clothes dryer)

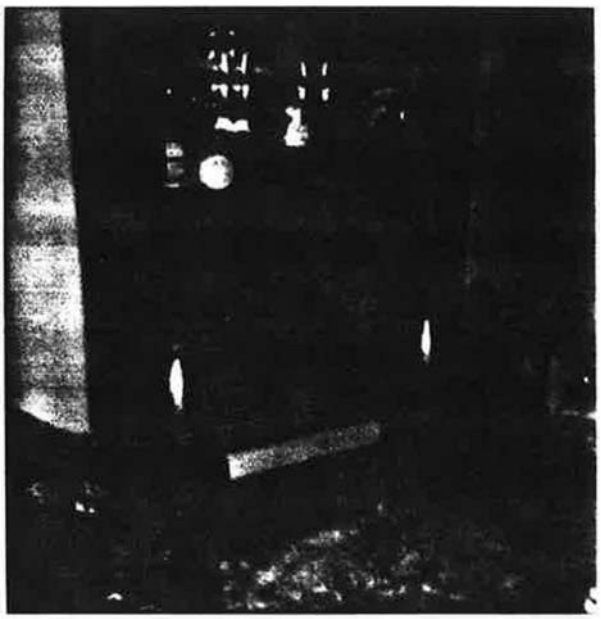
HOUSE DESCRIPTION

Counter Number: 21
House Location: William Street, North Vancouver, B.C.

- Basement: Crawl space, slab on grade
- Stories: 2
- Construction date: Post 1975
- Furnace: Gas-fired without flue damper
- DHW: Gas-fired
- Furnace Location: Main floor
- Furnace chimney on outside wall: No
- DHW & Furnace share chimney: Yes
- Outdoor portion of chimney is: Metal
- Approximate age of furnace: Less than 5 years
- Converted from oil heating to gas: No
- Furnace serviced: N/A
- Type of fireplace: 1. Wood stove, 2. Brick with doors
- Notice aroma of wood smoke during or after a fire: Common
- Exhaust fans: 3 (Kitchen range hood, bathroom exhaust, and clothes dryer)

HOUSE DESCRIPTION

Counter Number: 22
House Location: West 22nd Street, North Vancouver, B.C.



- Basement: Full
- Stories: 2
- Construction date: 1900 - 1945
- Furnace: N/A
- DHW: N/A
- Furnace Location: Furnace room in basement
- Furnace chimney on outside wall: No
- DHW & Furnace share chimney: Yes
- Outdoor portion of chimney is: Brick (or masonry)
- Approximate age of furnace: 5 to 10 years
- Converted from oil heating to gas: Unknown
- Furnace serviced: 2 to 3 years ago
- Type of fireplace: Brick with doors
- Notice aroma of wood smoke during or after a fire: Common
- Exhaust fans: 2 (Kitchen range hood and clothes dryer)

HOUSE DESCRIPTION

Counter Number: 23
House Location: Wellington, North Vancouver, B.C.

- Basement: Full
- Stories: 1
- Construction date: 1960 - 1975
- Furnace: Gas-fired without flue damper
- DHW: Gas-fired
- Furnace Location: Furnace room in basement
- Furnace chimney on outside wall: No
- DHW & Furnace share chimney: Yes
- Outdoor portion of chimney is: Metal
- Approximate age of furnace: 10 to 20 years
- Converted from oil heating to gas: No
- Furnace serviced: More than 3 years ago
- Type of fireplace: 1. Brick with doors, 2. Airtight insert
- Notice aroma of wood smoke during or after a fire: Rare
- Exhaust fans: 3 (Kitchen range hood, bathroom exhaust, and clothes dryer)

HOUSE DESCRIPTION

Counter Number: 24
House Location: Rosenberry Avenue, West Vancouver, B.C.

- Basement: Crawl space
- Stories: 2
- Construction date: 1960 - 1975
- Furnace: Gas-fired without flue damper
- DHW: Gas-fired
- Furnace Location: Main floor
- Furnace chimney on outside wall: No
- DHW & Furnace share chimney: Yes
- Outdoor portion of chimney is: Metal
- Approximate age of furnace: 5 to 10 years
- Converted from oil heating to gas: No
- Furnace serviced: N/A
- Type of fireplace: 1. Open brick, 2. Open metal
- Notice aroma of wood smoke during or after a fire: N/A
- Exhaust fans: 1 (clothes dryer)

5. REFERENCES

1. RESIDENTIAL COMBUSTION VENTING FAILURE: A SYSTEMS APPROACH, SUMMARY REPORT AND FINAL TECHNICAL REPORT FOR PROJECT 1: COUNTRY-WIDE SURVEY, Prepared for CMHC by Scanada Sheltair Consortium Ltd., January, 1987.

2. STANDARD CAN/CGSB 149.10 M: DETERMINATION OF AIR LEAKAGE BY THE FAN DEPRESSURIZATION METHOD, Canadian General Standards Board, 1986.

3. STANDARD CAN/CGSB 51.71: COMBUSTION VENTING REQUIREMENTS - A METHOD OF DETERMINING SAFE VENTING PRESSURES IN DWELLINGS WITH CHIMNEYS AND COMPETING EXHAUST DEVICES, DRAFT 2, Canadian General Standards Board, 1986.

A SURVEY OF FIREPLACE SPILLAGE INCIDENTS IN 24 HOUSES: FINAL REPORT

APPENDIX 1

INSTALLATION INSTRUCTIONS

MOUNTING INSTRUCTIONS

The spillage detector is designed to be hung above the fireplace, at a central location about 450mm (18 inches) above the upper lip of the fireplace opening. Ideally, the detector should be mounted on the face of the mantle, if one exists. Refer to the illustrations attached.

On the back of the grey box are two (2) hanging hooks. There are two options for hanging the detector from these hooks:

Option 1: Stretch a short piece of wire between the hooks and then hang the detector on a screw or nail, as you would a picture frame. This option requires that you install a screw or nail at this location. Sometimes a small masonry screw can be screwed into the grouting between bricks. Or a nail (with head) can be tacked into the top of the mantle at the well join. See what suits the particular fireplace, and carry nails and screws, as well as a drill, screwdriver, and hammer. If it is impossible to install a nail or screw without marring the surface, try Option 2.

Option 2: Attach two small nails or screws on either side of the fireplace wall or mantle, out of view. Then, stretch a wire from the left nail to the left hook on back of the detector, and a separate wire from the right hook to the right nail. In this way the detector is hung like a shirt on a clothes line.

The detector must be continuously powered. To ensure that the householder does not unplug the detector (so as to plug in a vacuum, say) we are providing octopus plugs. If the plug won't reach the nearest outlet use one of the small extension cords provided.

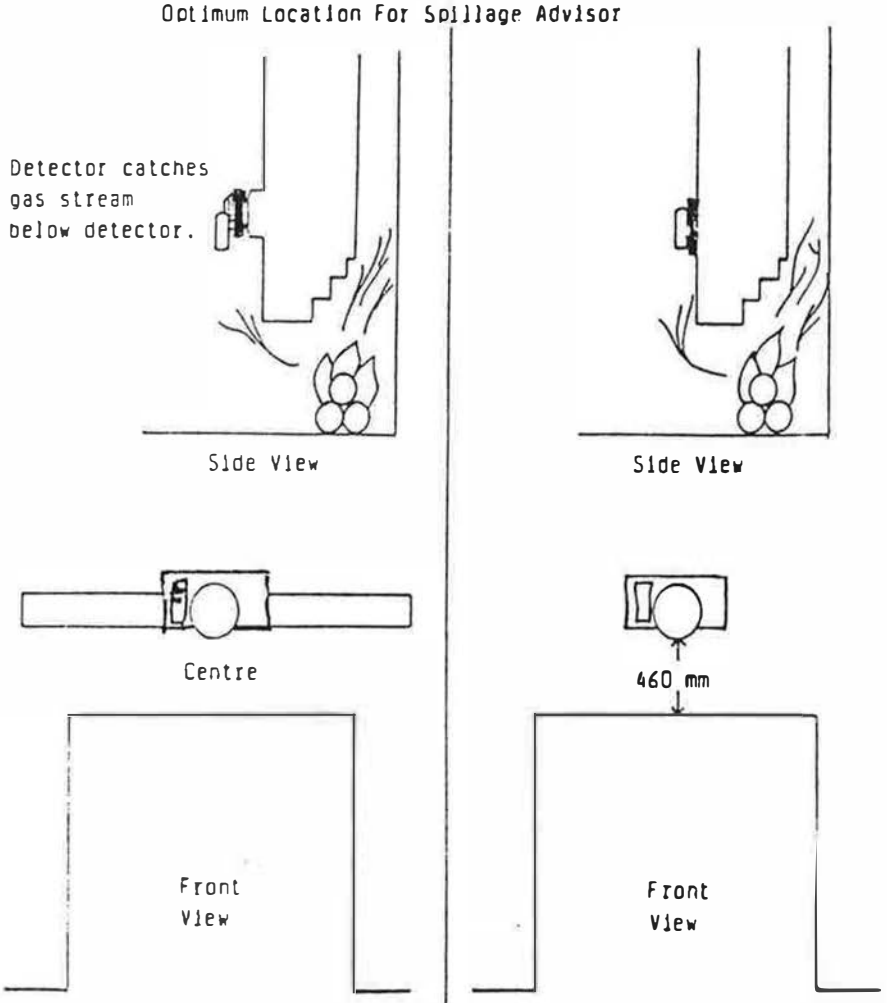
Start-Up:

When you plug in the detector, the red light on the CO monitor should come on. If it doesn't, then try another electrical outlet and if this fails, use another monitor.

This red light may flash. If it is flashing, counters 1 and 3 should advance 10 - 15 seconds after plugging in the detector. The light will flash and the counters will advance for approximately one (1) minute. Wait until they have stopped before recording the numbers on the counters. If the light flashes and counters 1 and 3 don't count, go on to another detector and give us a call. Any problems with these monitors can probably be fixed over the phone.

Finally, if the red light on the CO monitor doesn't flash, this is not a sign of a problem. Just proceed with the installation and tests.

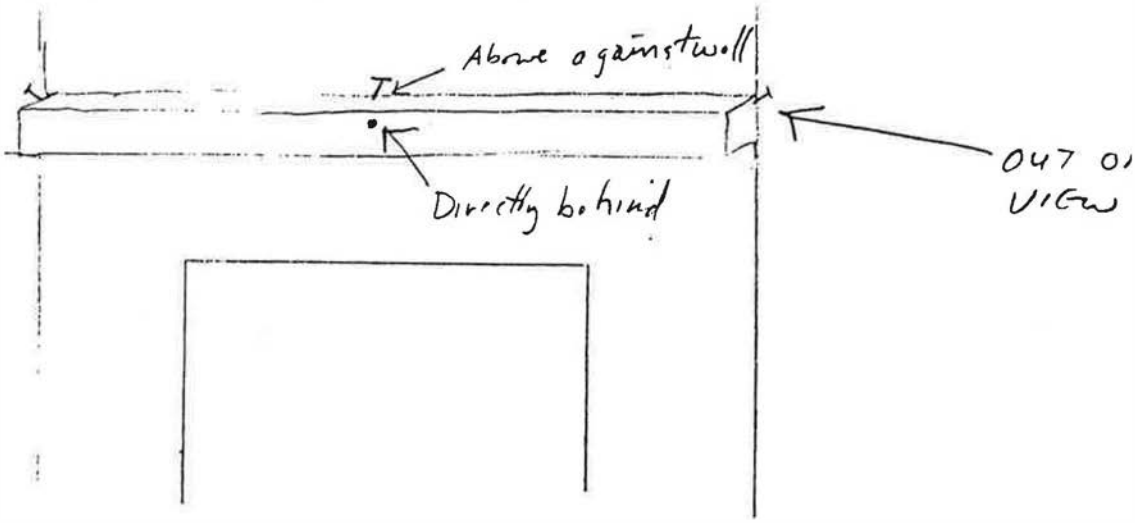
Optimum Location For Spillage Advisor



A. Fireplace with mantle.

B. Fireplace without mantle.

OPTIONAL HANGING NAIL LOCATIONS

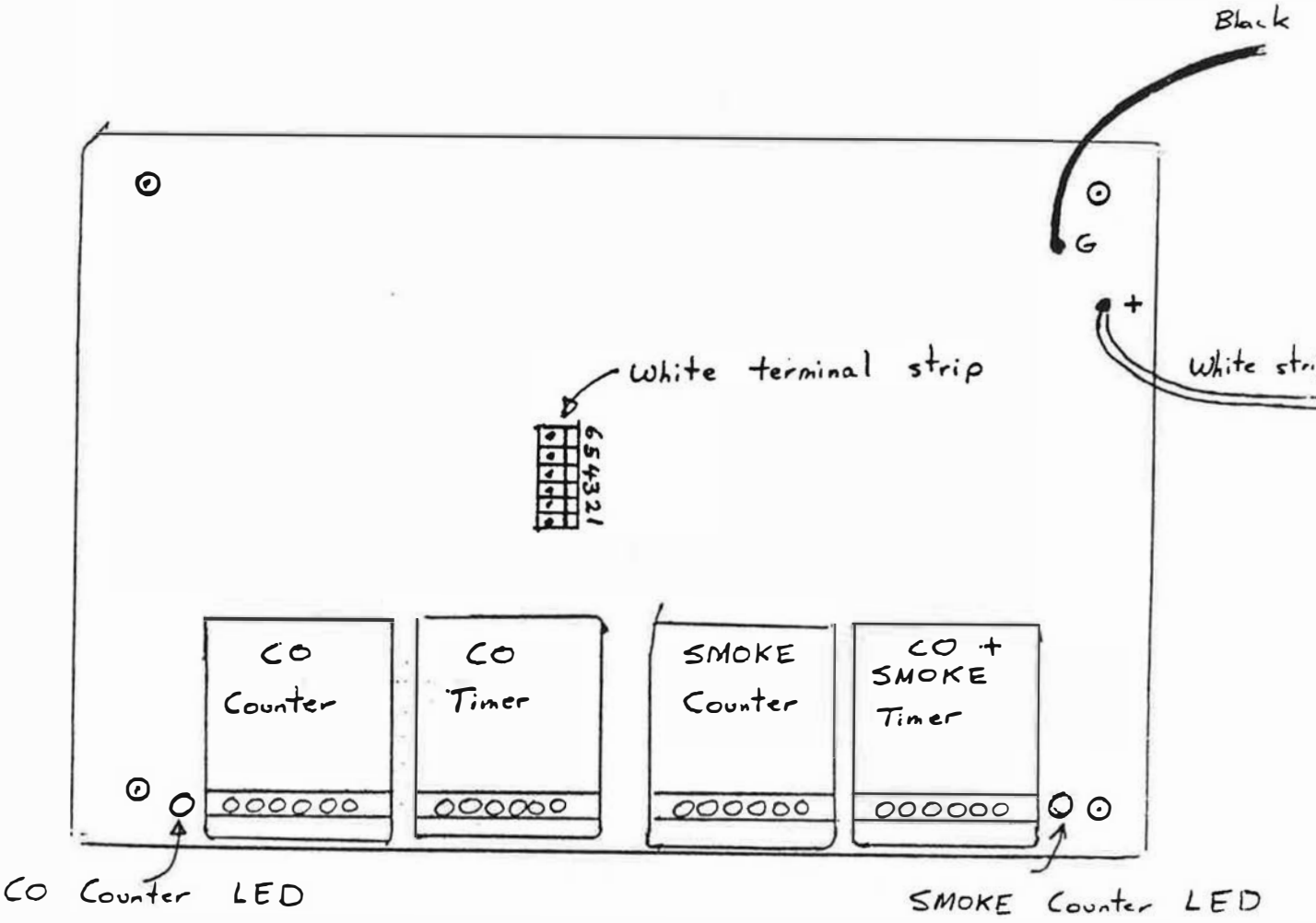


A SURVEY OF FIREPLACE SPILLAGE INCIDENTS IN 24 HOUSES: FINAL REPORT

APPENDIX 2

DETECTOR DESIGN

WIRING DIAGRAM FOR THE FIREPLACE SPILLAGE DETECTOR



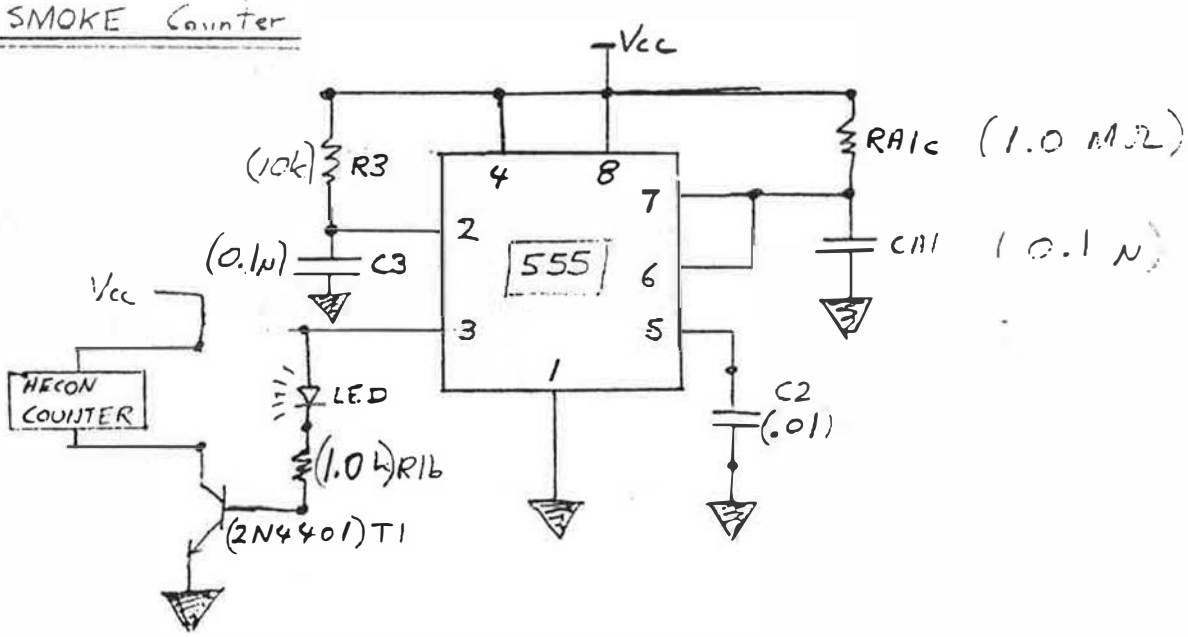
Terminal strip connections

Pin #	Connects to	Wire colour
1	Smoke alarm pin nearest battery	Grey
2	Smoke alarm center pin	G
3	CO white wire	G
4	CO black wire -(+ on CO P.C.B.)	G
5	CO Power cord +: white stripped wire	G
6	CO Power cord -: black	Red

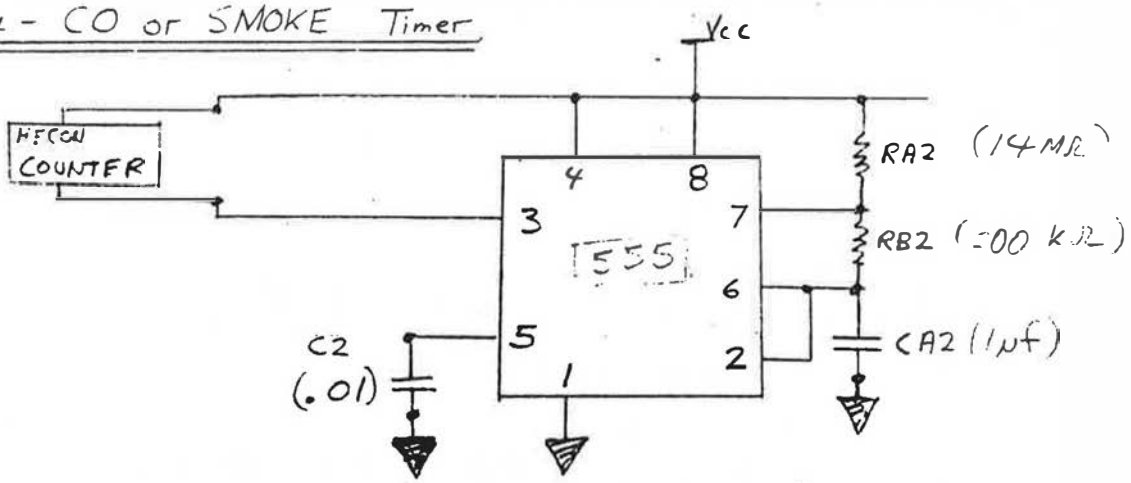
CO AND SMOKE COUNTER AND TIMER CIRCUIT - VERSION 4B

y P. Porter October 1986

chematic 3/4 - SMOKE Counter

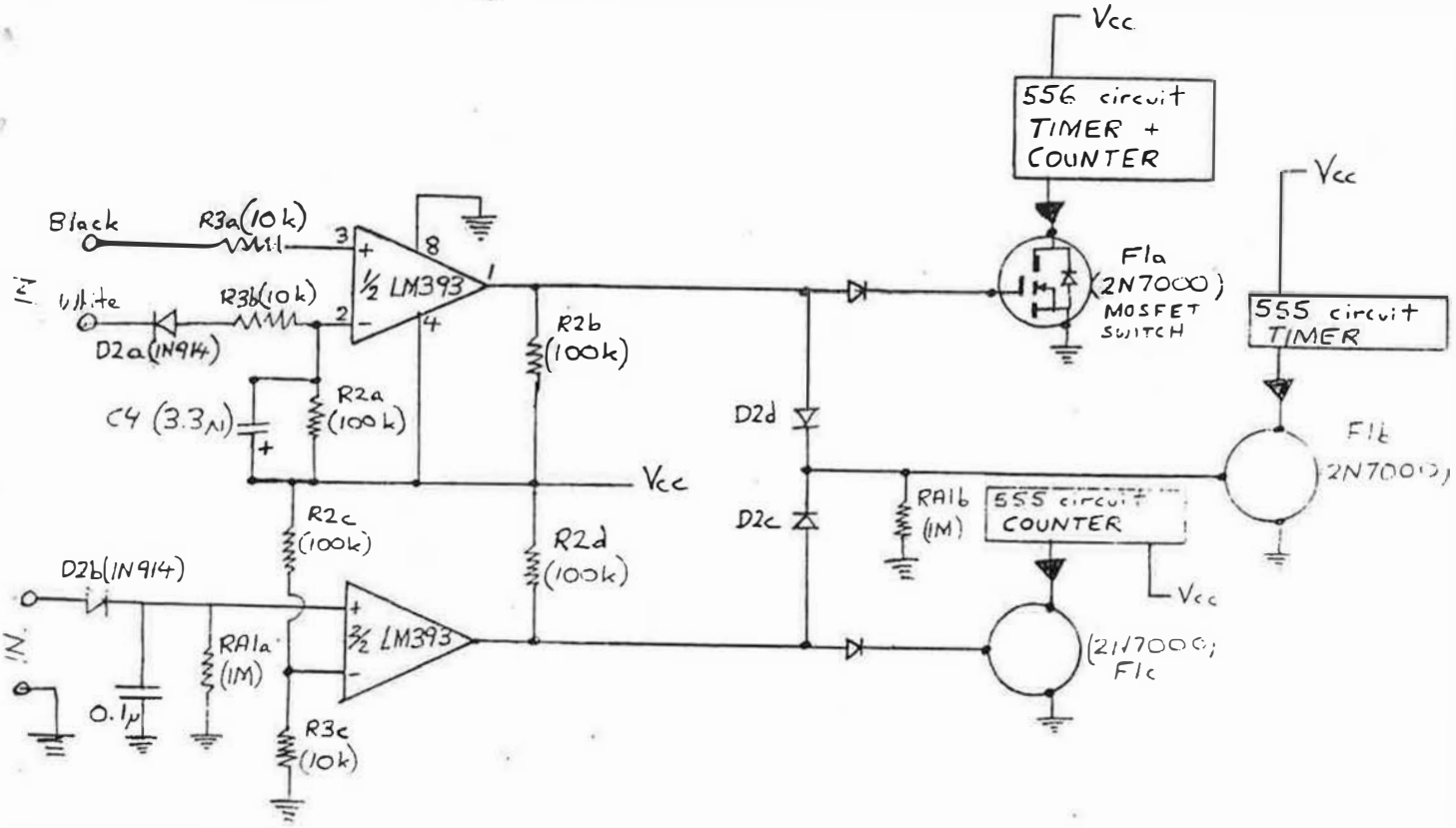


chematic 4/4 - CO or SMOKE Timer

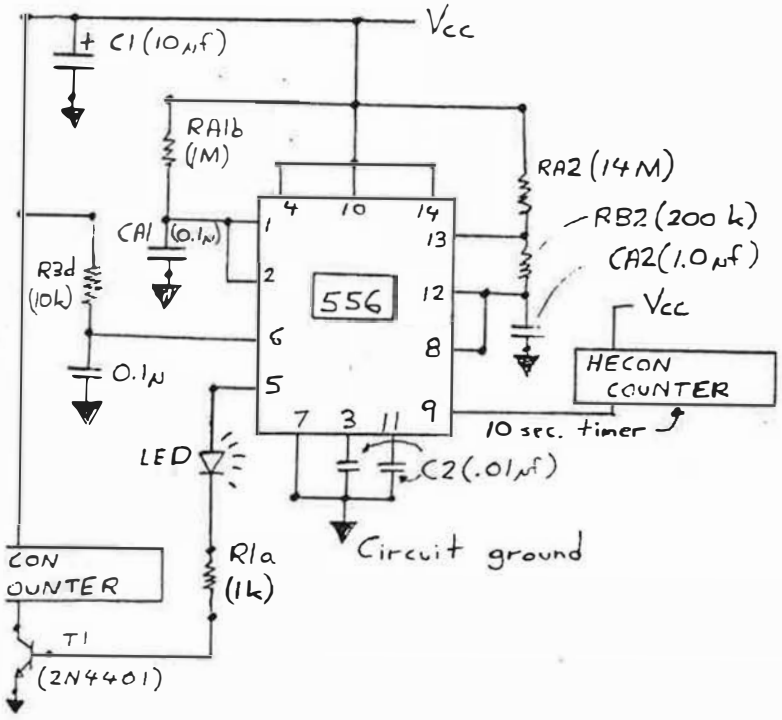


SCHEMATIC 1/4 - INPUT CIRCUIT AND SWITCHES

by P. Porter 14 January 1987



chematic 2/4 - CO Timer and Counter



NOTES

PARTS LIST FOR EACH COUNTER

Sheltair Counter Timer circuit Version 4

Parts List

Name	Part name	Quantity
1	556 timer	1
2	555 timer	3
3	LM393 comparator	1
4	14 pin dip socket	1
5	8 pin dip socket	3
F1	2N7000 FET	3
T1,T2	2N4401 Transistor	2
LED	Red LED	2
D1	1N4001	1
D2-D7	1N914	6
C3	0.1 uf (0.3" lead spacing)	2
C2	0.01 uf (0.3" lead spacing)	5
CA1	0.1 uf MKT (0.3" leads)	2
CA2	1.0 uf MKT 63v.	2
C1	10 uf/25 v. radial	3
C4	3.3 uf/25 v. radial	1
RA2	14.0 M 5% carbon/m.f.	2
RB2	200 k 1% m.f.	2
RA1	1.0 M 5% carbon	6
R1	1.0 k 5%	2
R2	100 k 5%	4
R3	10 k 5%	5
Molex bead pins 0.062" dia		2
Panduit 6 pin connector MLSS100-6-D		1
Panduit 6 pin connector CE100F26-6-D		1
18" flat cable Panduit 100F22V9-CUT		1
PC board mounting spacers 1/4 inch long		
	Johnson 313-6487-008	4
	6-32 * 5/8" round-hd screws	4
	6-32 nuts	4
PC board 6" by 4"	d drilled	
	213 holes	1