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DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH AND FIRE OFFICES' COMMITTEE
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# ROOF VENTING OF BURNING ENCLOSURES

## PART I. PRELIMINARY EXPERIMENTS USING SMOKE TRACER

D. L. Simms, P. L. Hinkley and Alison M. Bisset

Summary

Experiments are described in which flow patterns are studied in a vented compartment heated so that the bulk flow is two dimensional in a vertical plane. The most important factors in efficient venting are the sizes of the vent and of the inlet; the positions of the vent in the roof and of the fire within the model are only of minor importance.

In this type of flow the size of the vent necessary to prevent any spillover is independent of the floor area.

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## PART I. PRELIMINARY EXPERIMENTS USING SMOKE TRACER

by

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## 1. Introduction

The two main functions of roof vents are to enable firemen to enter a building by exhausting smoke and hot gases and to reduce the lateral spread of fire particularly when used in conjunction with fire curtains. Their effectiveness depends on many factors, for example, their size, shape and position, the depth and position of the fire curtains and the length of the enclosure. A comprehensive investigation of all the possible factors would require a prohibitive expenditure of time and effort. The experiments of this report were undertaken to find the more important factors by a qualitative investigation of the flow patterns in a heated compartment. The flow patterns were made visible by smoke.

The flow patterns in the model will be essentially similar to those in the prototype provided that the flow in the model is turbulent.

## 2. Construction of the model

A box, 3 ft x 1½ ft x 1½ ft was constructed from ½ in. thick asbestos wood. The two long sides of the box contained windows 2 ft x 1½ ft of glass shielded with perspex. The area and position of the vent could be varied by moving asbestos covers over the top of the box. A few experiments were carried out with the box extended to twice the length using aluminium foil panels.

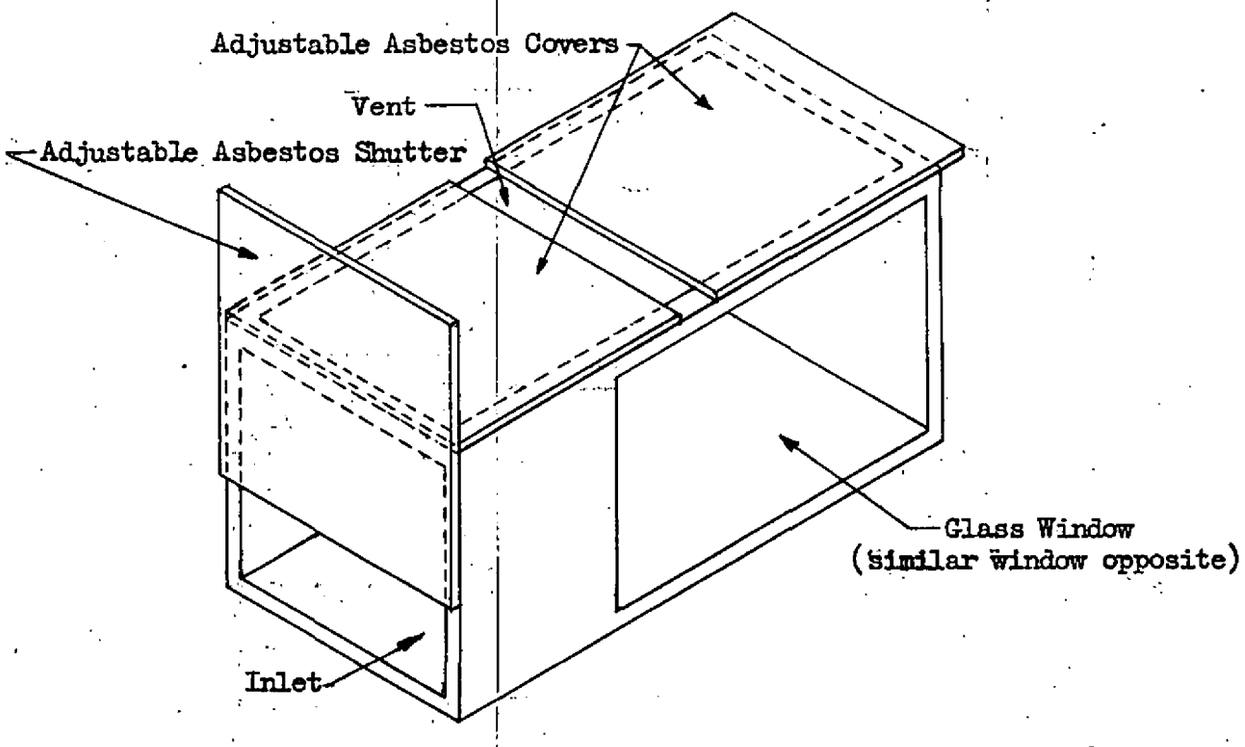


Figure 1. Model

The window on one side was covered by a diffusing screen marked with horizontal divisions, strongly illuminated from the rear.

## 3. Test procedure and results

Conditions in the compartment were allowed to reach equilibrium. Two smoke cartridges were placed on the floor of the box so that the jets of smoke passed through the heater. The openings were covered until the box was filled with smoke, the covers were removed and the resulting flow patterns observed.

The results are given in table 1 and figure 2.

Table 1. Experiments carried out and results

| Length (ft.) | Position of heater | Height of Inlet (in.) | Position of Vent | Width of Vent (in.) | Approximate height of layer of clear air (in.) | Smoke issuing from inlet | Type of smoke pattern (fig. 2) |
|---|---|---|---|---|---|---|---|
| 3 | Centre | No inlet | No vent | | None | - | A |
| | Centre | 1 to $4\frac{1}{2}$ | No vent | | Not measured | Top of inlet | B |
| | Far end | 3 | No vent | | 1 | Top of inlet | C |
| | " | $6\frac{1}{2}$ | " | | 3 | " | |
| | | 7 | " | | 4 | " | |
| | | 8 | " | | 5 | " | |
| | Far end | $2\frac{1}{2}$ | Far end | 1 | 3 | None | D |
| | " | $2\frac{1}{2}$ | " | 2 | 5 | " | D |
| | " | $4\frac{1}{2}$ | " | 1 | 3 | " | D |
| | " | $4\frac{1}{2}$ | " | 2 | 6 | " | D |
| | " | $2\frac{1}{2}$ | Centre | 1 | 3 | " | E |
| | " | $2\frac{1}{2}$ | " | 2 | $4\frac{1}{2}$ | " | E |
| | " | $4\frac{1}{2}$ | " | 1 | $5\frac{1}{2}$ | Very slight | E |
| | " | $4\frac{1}{2}$ | " | 2 | $6\frac{1}{2}$ | None | E |
| | Centre | $2\frac{1}{2}$ and $4\frac{1}{2}$ | Far end | 1 and 2 | Not measured | None | F |
| | " | $2\frac{1}{2}$ | Centre | 1 and 2 | " " | None | G |
| | " | $4\frac{1}{2}$ | " | 1 | " " | top 1" | G |
| | " | $4\frac{1}{2}$ | " | 2 | " " | top $\frac{1}{2}$" | G |
| | " | $4\frac{1}{2}$ | Near end | 1 | " " | top $\frac{1}{2}$" | H |
| | " | $4\frac{1}{2}$ | " | 2 | " " | None | H |
| | Far end | No inlet | Two vents one at each end | 2 | None | - | K |
| | Far end | 5 | Far end | 0.9 | Not measured | Just not issuing | C |
| | " | | Near end | 0.9 | | | |
| | Far end | 9 | Far end | 2.8 | Not measured | Just not issuing | C |
| | | | Near end | 2.9 | | | |
| 6 | Far end | 5 | Far end | 1.1 | Not measured | Just not issuing | C |
| | | | Near end | 1.2 | | | |
| | Far end | 9 | Far end | 3.5 | Not measured | Just not issuing | C |
| | | | Near end | 3.2 | | | |

## 4. Experimental observations

### 4.1. No openings

When there were no openings in the model the high temperature smoke rose vertically and became turbulent at about $\frac{1}{3}$ of the height of the model (Fig. 2A). The hot smoke spread beneath the ceiling and then slowly circulated in the main volume of the box.

### 4.2. Inlet only

When the inlet was opened (Fig. 2 B & C) a layer of clear air flowed along the floor towards the heater and smoke "spilled" under the top edge. Over the greater part of its path the height of the layer of clear air was about half the height of the inlet. There was only slight mixing with the smoke layer at the horizontal boundary between the two streams.

### 4.3. Inlet and vent

When a vent was opened, the height of the clear layer increased (Fig. 2D) to a level which depended on the size of the vent and on the height of the inlet. The position of the vent had only a minor effect (Figs. 2D-H). A stream of hot smoke from the heater flowed beneath the ceiling towards the vent. The remainder of the model was filled with a slowly circulating volume of smoke less dense than that in the main stream. A "spillage" of smoke under the top edge of the inlet was most likely to occur when the heater was in the centre of the model. (Fig. 2 F & H). Although the new flow pattern was quickly established on opening the vent some time elapsed before smoke cleared from the relatively stagnant areas. Clearance from these areas is by turbulent mixing rather than by plug flow in the main flow paths.

### 4.4. Two vents, no inlet

When there were two openings in the roof and none in the walls the smoke was vented through the opening nearer the heater and cold air entered through the other (Fig. 2K). This air soon mixed with the circulating smoke in the box and there was no definite clear volume near the floor.

## 5. Discussion and conclusions

Adequate openings at ground level are essential if vents are to clear smoke. There should then be "lanes" of clear air through which firemen can advance on the fire at a height controlled by the height of the inlet as well as the size of the vent.

The position of the vent appeared to be of minor importance because of the almost complete absence of mixing between the hot and cold zones. Doubling the length of the model only resulted in a slight increase in the area of the vent required to prevent spillover. This was probably due to the slight increase in mixing between the hot and the cold zones with length.

The existence of a relatively stagnant area behind the heater when the heater was in the centre of the model and inlet was in front of the heater (Fig.2G) implies that the same result would be obtained with a shortened model having the heater at the rear. Partly because of this and partly because of the relative unimportance of the position of the vent the position of the heater is only of minor importance.

In this model with two dimensional flow and the low heat losses, the critical vent area is not a function of the floor area but this may not be true when the flow is radial or the length/height ratio is larger.

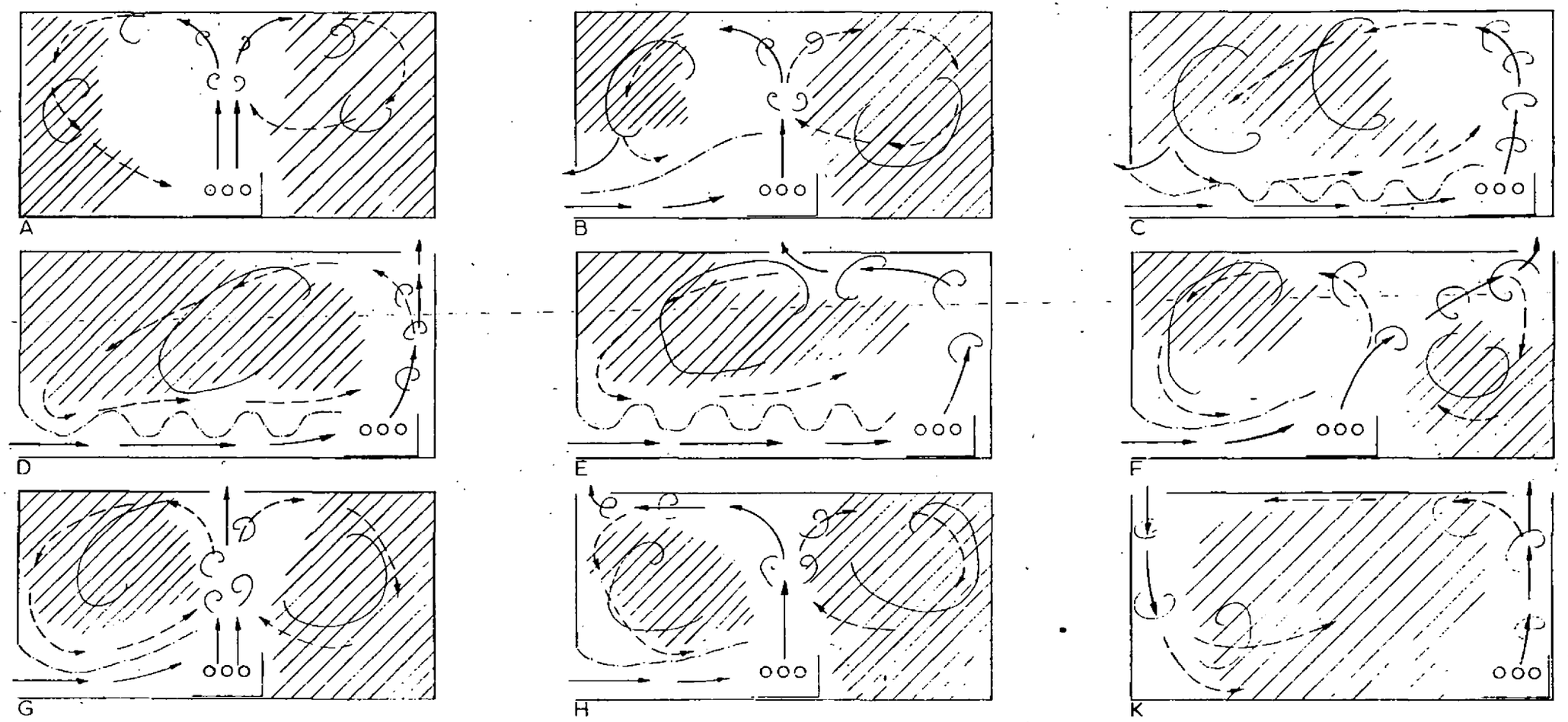


FIG. 2 FLOW PATTERNS