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DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH AND FIRE OFFICES' COMMITTEE
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ON THE PREVENTION OF FLAME SPREAD BENEATH CEILINGS IN FULLY DEVELOPED FIRES BY ROOF VENTS

by

P. H. Thomas and D. L. Simms

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SUMMARY

If, in a large compartment, there are curtains extending from the ceiling towards the floor and one of the sub-compartments is involved in fire, flames and heat may spread under the curtain to the next sub-compartment. Some small-scale experiments are reported in which the curtain sizes for different vent conditions to prevent this spread were studied.

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1. Introduction

Recent legislation (1) and recent fires (2)(3) have focussed attention on the problem of preventing fire spread in large buildings with large open areas.

Among the suggestions that have been made to control or prevent such fires is the installation of roof vents, either by themselves or with curtains extending down from the ceiling towards the floor. The function of the vents depends on the development of the fire; they may be used to clear smoke so that the fireman can see the fire or prevent fires from spreading by exhausting the heat. Curtains enable the vents to act as more efficient chimneys. They may extend down only as far as the trusses or they can be lowered in the event of fire to much nearer the floor.

The particular problem investigated in the present paper was to find the depth of curtain required to prevent passage of flame beneath the curtain for different sizes and positions of the vent.

A programme of this kind on a larger scale is not at present feasible, so that the present experimental results have to be considered as tentative.

2. Experimental arrangement

The apparatus used is shown in Fig. 1 and Plate 1. The dimensions of the box were 2 ft 6 in. x 1 ft 6 in. x 1 ft 6 in. with sides of 0.5 in. thick asbestos board. The roof consisted of separate pieces of asbestos board any one of which could easily be removed. The front of the box had a sliding curtain which could be adjusted at 2 in. distances from the floor with a minimum distance of 6.5 in. A fully developed fire was simulated by using town gas; this entered the box through a pipe and was distributed over the floor area of the box by jets broken up by fire brick. The flow of gas was metered.

3. Roof vents and curtains

3.1. Results

The gas flow was increased until flame filled the box and appeared from both the front of the box and the largest vent it was intended to use; and the bulk of the experiments were performed with a flow of 800 ft^3/hour. At the beginning of each experiment the size and position of the vent was fixed, the curtain was then lowered until no flames appeared from beneath it. The experiment was then repeated for a range of sizes and positions of the vents, and also with a slightly lower rate of gas flow. The experiments carried out and their results are listed in Table 1.

Table 1

Gas flow (ft^3/h)	Exp. No.	Size of vent (in.)	Distance of rear edge of vent from front (in.)	Height of opening in front (in.)	Conditions at inlet
800	1	3	21	6.5	Occasional wisps of flame emerged.
800	2	3	15	6.5	No flames
800	3	3	9	8.5 6.5	Thin wispy flames. No flames.
800	4	6	21	12.5 10.5	Thin wispy flames. No flames.
800	5	6	15	14.5 12.5	Thin wispy flames. No flames.
800	6	6	9	16.5 14.5	Thin wispy flames. No flames.
800	7,8,9	9	21, 15, 9	Fully open (18)	No flames with any position.
700	10	3	21	8.5 6.5	Wispy flames. Almost none.
700	11	3	15	8.5 6.5	Wispy flames. No flames.
700	12	3	9	8.5 6.5	Smoke. No flames.
700	13 - 19	6,9	21, 15, 9	Fully open (18)	No flames with any position.

3.2. Velocity of air at inlet

The apparatus was set up with the curtain in its lowest position (6.5 in. from the floor) and the gas flow adjusted to 600 ft^3/h. The variation of inlet air velocity with height in the plane of the curtain was measured by a radiation compensated anemometer (4). The velocity decreased from about 1.2 ft/s near the base to about 0.7 ft/s near the bottom of the curtain, some edge effects are noticeable. The mean value of the inlet velocity was 1 ft/s approximately.

4. Discussion of results

For venting to be effective, the vent needed to be about half the size of the curtain opening. Its position did not appear to be critical although it was slightly more effective when near to the curtain.

The inlet velocity and the flow pattern of the turbulent system are determined by the buoyancy head and the fuel flow.

If the momentum of the fuel flow may be neglected, the inlet flow is proportional to the square root of the height, so that the full-scale burning rate of which this model is representative is also proportional to the square root of the height. Keeping the air/fuel ratio constant ensures to a first approximation similarity of mixing patterns and of temperature distribution because the heat release per unit volume of the enclosure will also be constant.

It is probable that the results obtained in the present experiments may be applied on full-scale, but some confirmatory experiments are necessary.

The rate of burning in the model $2\frac{1}{2}$ ft x $1\frac{1}{2}$ ft x $1\frac{1}{2}$ ft high of 800 ft^3/h of gas of density 0.07 lb/ft^3, is equivalent to a rate of burning of 1 lb min^{-1} per sq. ft of floor area in a 25 ft high building. The volatiles from wood require approximately the same amount of air for combustion (to within 30 per cent) as does town's gas. The equivalent large-scale fire is thus burning wood at 1 $lb/ft^{-2}/min^{-1}$. Some experiments now in progress suggest that peak burning rates for wood may be as high as 0.1 - 0.2 lb/min. per sq. ft of wood surface, so the fire used would have an effective fire load of 8 lb/ft^2 of 1 in. to 2 in. section timber. On the assumptions that have been discussed above, the velocity of the inlet air scales as the square root of the height and on full-scale would therefore be about 4 ft/s.

5. References

1. Thermal Insulation (Industrial Buildings) Act, 1951.

2. ASHTON, L. A. and LANGDON THOMAS, G. Fire at the Jaguar Factory, Coventry. Engineer, Lond., 1957, 204 (5300) 273.

3. General Motors Corporation Fire, Livonia, Michigan. U.S. Factory Insurance Asscn., 1953.

4. BIGMORE, R. H. A radiation compensated anemometer. Joint Fire Research Organization. F.R. Note No. 297/1957.

6. Acknowledgments

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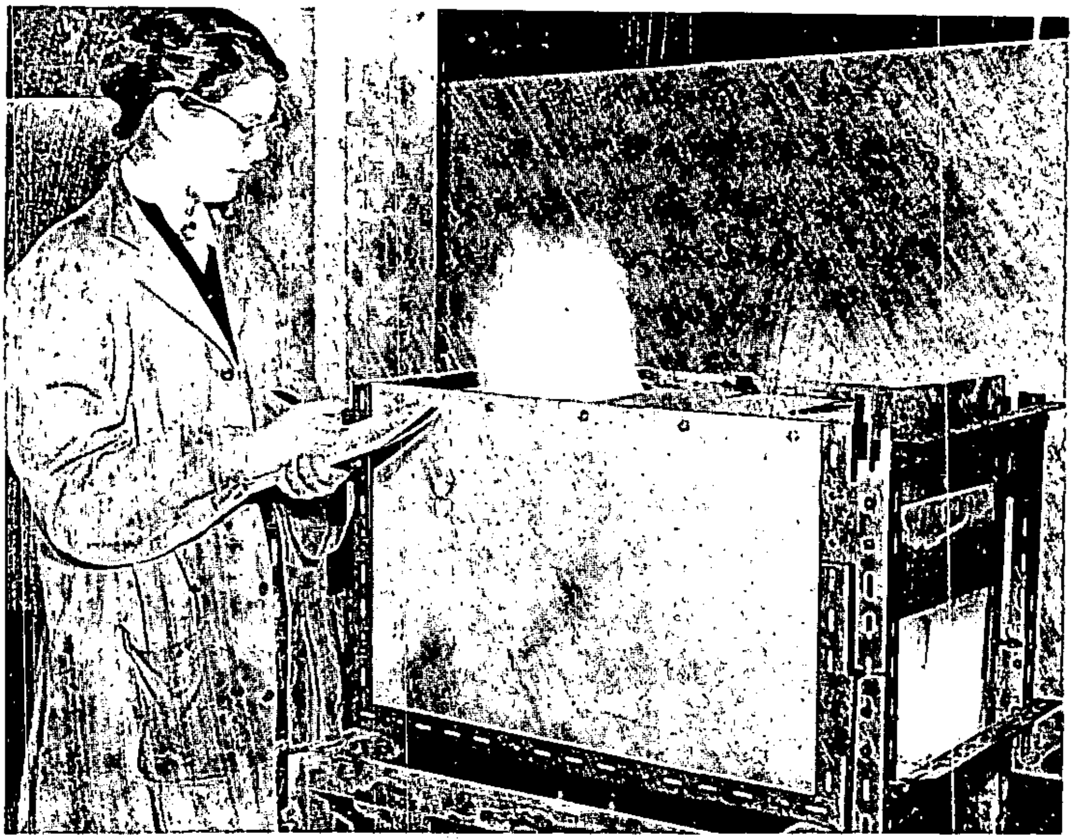

PLATE. I. A VENT IN ACTION