DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

AND

FIRE OFFICES' COMMITTEE

JOINT FIRE RESEARCH ORGANIZATION

FIRE RESEARCH NOTE

NO. 550

CONTROL OF FIRES IN LARGE SPACES WITH INERT GAS AND FOAM PRODUCED BY A TURBO-JET ENGINE

(9) THE DISTRIBUTION OF GAS AND CONTROL OF FIRES IN A MULTI-STOREY BUILDING

by

G. W. V. STARK AND J. F. CARD

May, 1964.

Fire Research Station.
Boreham Wood.
Herts.
('phone ELStree 1341)

F.R. Note No.550

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH AND FIRE OFFICES' COMMITTEE
JOINT FIRE RESEARCH ORGANIZATION

CONTROL OF FIRES IN LARGE SPACES WITH INERT GAS AND FOAM PRODUCED BY A TURBO-JET ENGINE

(9) THE DISTRIBUTION OF GAS AND CONTROL OF FIRES IN A MULTI-STOREY BUILDING

by

G. W. V. STARK AND J. F. CARD

SUMMARY

A series of tests were made to study the extinction of fires in a four-storey tower. The extinction of flaming combustion in an 850 ft^3 room with a 14 ft^2 open window requires the supply of inert gas containing 7 per cent oxygen at about 2500 ft^3/min. Fires on different floors could be controlled readily, when inert gas in sufficient quantity was introduced at ground level.

CONTROL OF FIRES IN LARGE SPACES WITH INERT GAS AND FOAM PRODUCED BY A TURBO-JET ENGINE

(9) THE DISTRIBUTION OF GAS AND CONTROL OF FIRES IN A MULTI-STOREY BUILDING

by

G. W. V. STARK AND J. F. CARD

Introduction

The results of tests on the control of fires in single storey buildings and basements have been reported elsewhere[1, 2]. The present note describes a short series of tests undertaken to assess the distribution of inert gas in the four-storey tower at the Fire Research Station, and to determine the rate of flow of inert gas required for the extinction of flaming combustion of timber fires.

Experimental

The experiments were conducted in the four-storey tower at the Fire Research Station, Fig. 1, Plate 1. The tower consists of one room on each of the four floors, and a communicating staircase. A doorway of about 16 ft^2 area opens from the staircase into each room, with a window opening opposite the door. The upper window openings were each about 14 ft^2 and the ground floor window opening was 16 ft^2. The tower is described in greater detail elsewhere[3].

Tests were designed to determine:-

(1) the minimum rate of flow needed to replace the atmosphere with inert gas on all floors open to this stream of inert gas.

(2) the minimum rate of flow to a single floor to extinguish flaming combustion of cellulosic materials, (timber and fibreboard).

(3) the ability of inert gas to extinguish flaming combustion of cellulosic materials on different floors when the gas was introduced through the ground floor window and when all floors were open to the inert gas.

For the first group of these tests, the doors of the three upper rooms on to the communicating staircase were wedged open, and the windows of the rooms were also left open. Inert gas was introduced through flexible ducting sealed into the first landing window at X, Fig. 1 (Plate 1). This point of entry was used because the ground floor room had been sealed at the stair-way entrance in connection with another series of experiments. Inert gas was introduced and the minimum rate of flow giving uniform distribution was determined.

For the second group of tests, the conditions were as for group 1, except that the doors from the stair-well to the third and fourth storey rooms were closed. Two 3 ft cube crib fires of 1 in. square timber were built in the second storey room, and the walls were lined with ½ in. fibre board. The total fire load was about 500 lb. Inert gas was introduced so as to determine the minimum rate for extinction of flames.

For the third group of tests the seal isolating the ground floor room from the staircase was removed. Timber fires of about 300 lb load were constructed in the second and fourth storey rooms, and the doors to all four rooms from the staircase were wedged open. Inert gas was introduced through flexible ducting inserted through the 16 ft^2 open ground floor window, Plate 2. The duct was not sealed into this opening. Whipping of the duct was prevented by attaching a nylon-mesh bag to the end of the duct, so as to diffuse the emerging gas and thus reduce the reaction in the duct. Inert gas was introduced at a high rate of flow and the progress of extinction followed by observation and by a cine-film record.

The low rates of gas flow used in these tests were measured by a simple orifice plate inserted in the flexible ducting from the outlet of the jet engine generator. Full rates of flow were calculated from the measured rates of flow of air and fuel in the jet engine and reheat sections, the water consumption and the temperature of the inert gas produced(4).

Results

1. Inert Gas Distribution

Inert gas was introduced at low flow rates, and the appearance of steam at the upper three windows was observed. When inert gas containing 10 per cent oxygen was introduced at rates reducing from 10,000 ft^3/min to about 4,000 ft^3/min, the steam issued at similar rates from each of the three upper windows. This was the minimum rate of flow of gas examined, as at this time the rate of flow could not be set to lower values with any accuracy.

2. Extinction of Flames in a Single Room

The fire of 500 lb timber and fibre board was ignited and allowed to burn until flames had been coming out of the window for 2 minutes. Inert gas containing 10 per cent oxygen was then injected at 4,000 ft^3/min. The flames decreased in size until after 15 to 20 seconds of inert gas injection no flames were visible. Inert gas injection continued for a total time of 2 min. 30 sec when it was stopped. The fibre board reignited 30 seconds later and the wood cribs were burning well, with large flames, 8 min. 30 sec after injection was stopped. The inert gas was reintroduced, 14 min. 5 sec after being stopped, at 2,600 ft^3/min. Some control of the fire was obtained at first; the flames were pushed towards the window, and the atmosphere in the room remained fairly clear. However, as injection of gas continued, the flames increased in size and developed to about the same size as those of the free burning fire, but were thinner and redder in colour and more translucent. The supply of inert gas was stopped after 5 min. injection.

3. Extinction of Flames in 2nd and 4th Storey Rooms

A preliminary test was made before attempting to extinguish fires, to determine the distribution of gas between the rooms. Inert gas containing 10 per cent oxygen was injected at 40,000 ft^3/min into the building through the ground floor window, and the temperatures reached in the doorways of the four rooms was measured. In this test an 8 ft^2 shutter was left open on the stairway on the second storey level but was closed for the subsequent test. The temperatures recorded are given in Fig. 2. During this test the duct system was stable and did not whip. The rate of rise of temperature indicated a rapid distribution of gas to all floors; this was confirmed by observation of steam issuing from the windows. Steam emerged from the ground floor window, where the duct was introduced, at a very high rate, but the steam issued from the upper windows at what appeared to be a similar rate to that from the single room in the previously mentioned test.

The fire extinction test was then proceeded with. The fires were ignited in the second and fourth storey rooms, and allowed to burn for 12½ minutes.

Inert gas containing 10 per cent oxygen was then injected into the ground floor room at 40,000 ft^3/min at an indicated temperature of 85°C. The bulk of the gas was seen to escape as steam from the ground floor window, but steam issued from all windows in a few seconds no flames being seen at this point. The flow of gas was stopped after 1 min. 30 sec, when the steam cleared immediately, and the fires were seen to be still burning vigorously. The flow of gas into the building was then restarted 15 seconds later, and continued for a further 1 min. 30 sec. The film record of this part of the test showed that the flames from the fire in the second storey room were becoming thin and reducing in size in 5 seconds. After a further 5 seconds, no flames were visible, except possibly an occasional very small flickering flame. No flames were visible towards the end of the period of injection. The flow of gas into the building was then stopped for 30 seconds, but no flames were seen from either fire. Injection of the 10 per cent oxygen gas was continued for a further 1 min. 30 secs, when the gas was changed to one containing 16 per cent oxygen at about 27,000 ft^3/min. The photographic record and observation showed that flaming combustion of the wood was gradually re-established. Temperatures measured in the second storey room confirmed the observation and photographic records of the control of the fires, and a sharp rise in temperature indicated that burning was resumed after 2 min. injection of the 16 per cent oxygen gas. Injection of gas was stopped 5 min. later and the fires allowed to burn out.

Discussion and Conclusions

The first two groups of tests indicated that an even distribution of gas to three rooms was obtained with the introduction of 4,000 ft^3/min of inert gas, and that, in a single room, the flames from timber fires could be extinguished with inert gas containing 10 per cent oxygen at a rate intermediate between 4,000 ft^3/min and 2,600 ft^3/min. Assuming that the critical rate for flame extinction was the intermediate value, 3,300 ft^3/min, extinction with the most inert gas produced by the jet engine generator, containing 7 per cent oxygen, would be expected at a rate of 2,300 to 2,500 ft^3/min.

In the last test reported, in which inert gas containing 10 per cent oxygen was distributed through the whole of the four-storey building, the fires were less readily controlled than in the single room test, implying a rate of flow to each room somewhat less than 4,000 ft^3/min but greater than 2,600 ft^3/min. The amount of gas escaping from the ground floor window would therefore have exceeded 70 per cent of the gas delivered through the ducting.

It is concluded from these tests that inert gas from the jet engine generator can be introduced into a multi-storey building, and may be distributed laterally, for example from a stair-or lift-well, through a number of floors. The number of floors to which the gas may be introduced is dictated by, firstly, the need to introduce sufficient inert gas to any floor to exercise control over fires, i.e. to extinguish flaming, but not smouldering, combustion, and secondly, the pressure loss and hence the height and width of the stair-or lift-well, controlling the flow of inert gas. The flow of gas laterally would however be reduced if a large vent existed at the top of the stair-or lift-well. On a single level, since 2,300 - 2,500 ft^3/min of inert gas containing 7 per cent oxygen would extinguish flaming combustion in one room with a 14 ft^2 open window the total output of the jet engine generator, 45,000 ft^3/min, might be expected to extinguish flaming combustion in 15 to 20 such rooms.

Acknowledgements

Thanks are due to Messrs. B. Langford, D. Freeman and J. F. Richardson who assisted in the experimental arrangements.

References

(1) F.R. Note (In Preparation). "Control of Fires in Large Spaces with Inert Gas and Foam produced by a Turbo-jet Engine (4) Performance Tests with Inert Gas in the Models Laboratory", Fire Research Station.

(2) F.R. Note No. 527. "Control of Fires in Large Spaces with Inert Gas and Foam produced by a Turbo-jet Engine (6) Trials in Collaboration with the London Fire Brigade at disused Basement Premises". D. J. Rasbash, G. W. V. Stark, G. H. J. Elkins and B. Langford.

(3) F.R. Note No. 279. "A Multistorey Building for Experiments on the Spread of Fire and Smoke". L. A. Ashton.

(4) F.R. Note No. 507. "Control of Fires in Large Spaces with Inert Gas and Foam produced by a Turbo-jet Engine (1) Introduction and Properties of Inert Gas and Foam". D. J. Rasbash.

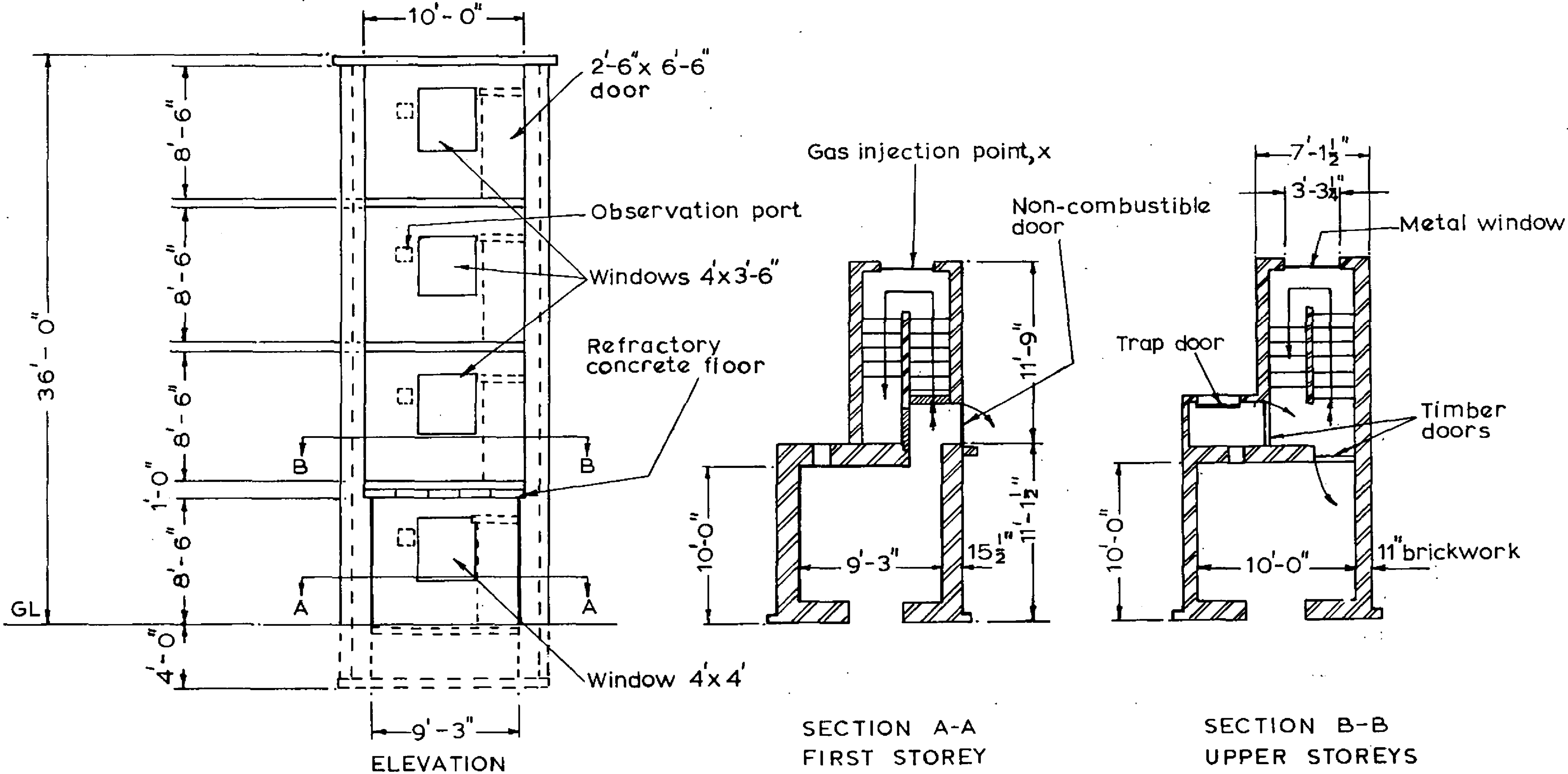


FIG.1. FOUR STOREY BUILDING FOR INERT GAS TESTS

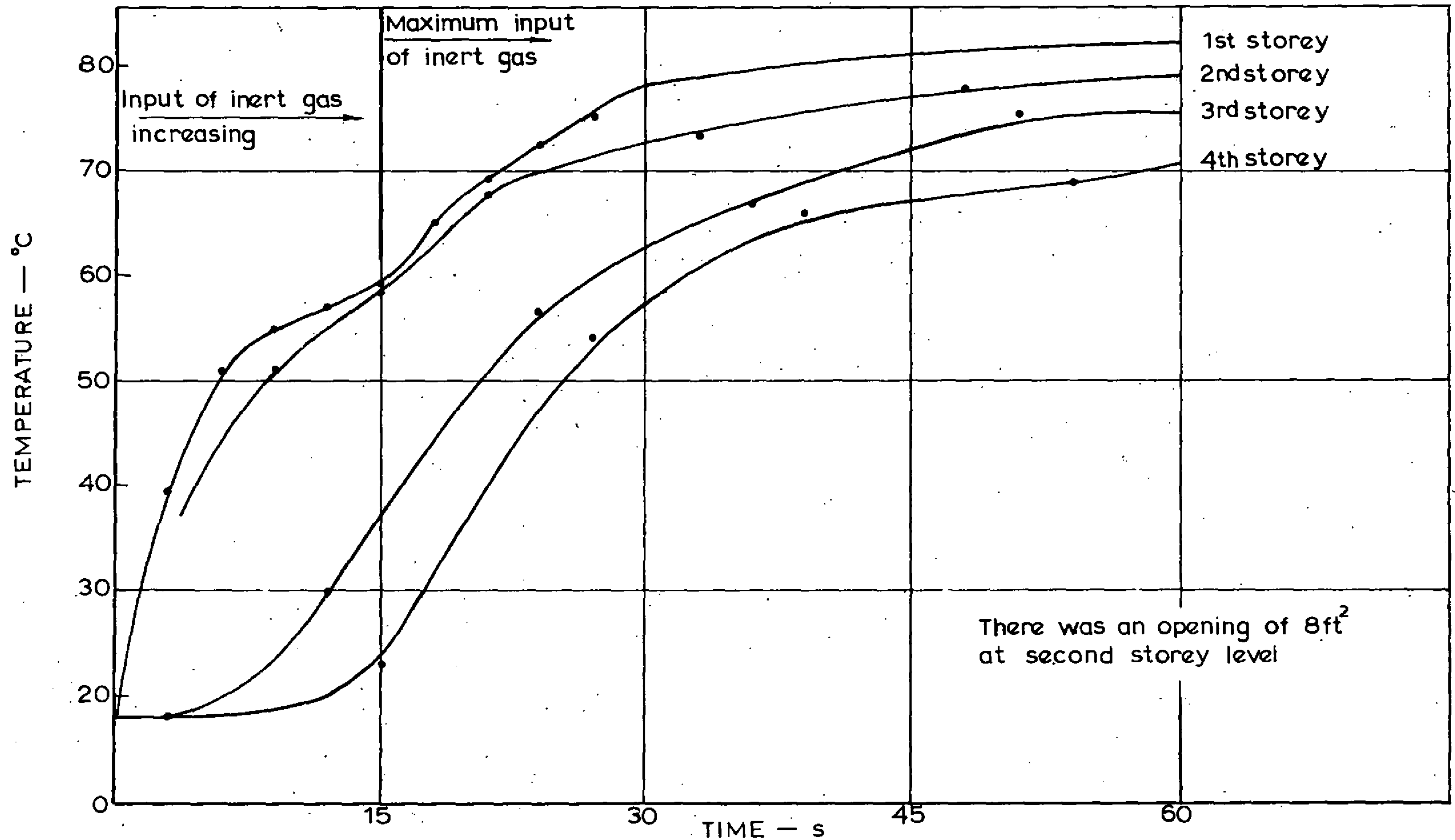
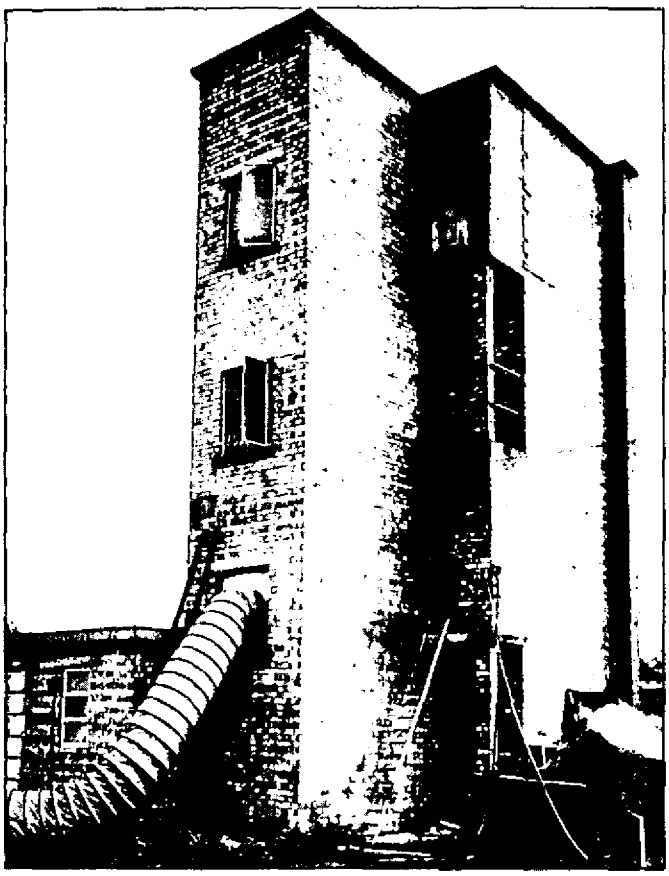
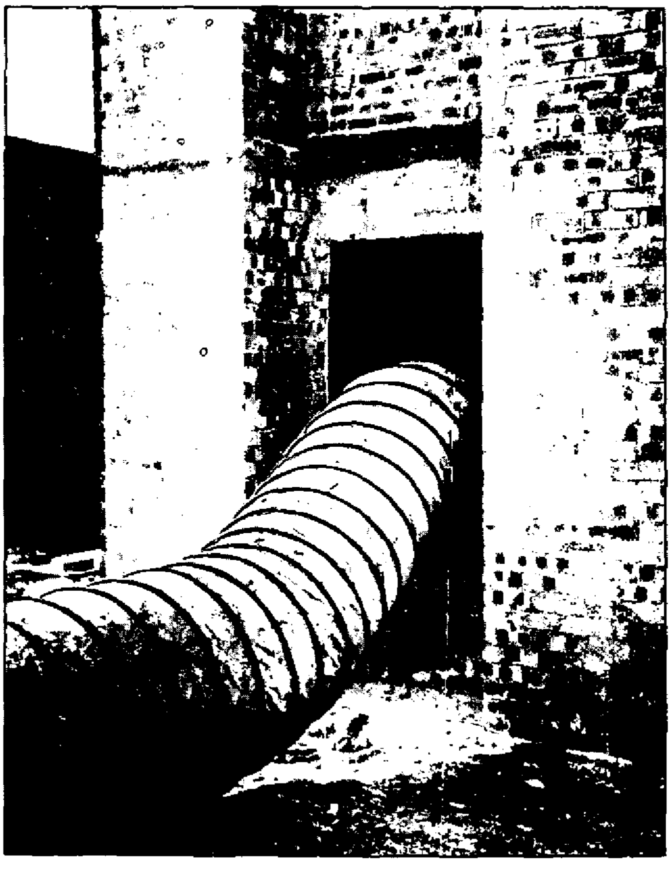


FIG. 2. INJECTION OF INERT GAS INTO FOUR-STOREY TOWER. TEMPERATURE AT DOORWAYS OF ROOMS



4 Storey tower

Entry of flexible duct to stairwell



4 Storey tower

Entry of flexible duct through ground floor window

PLATE 2