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The testing of whole houses for air leakage

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THE TESTING OF WHOLE HOUSES FOR AIR LEAKAGE

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SUMMARY

The possibility of reduced energy consumption through the control of excess air infiltration indicated a need to know about the air leakage characteristics of building envelopes generally.

A portable air leakage apparatus capable of measuring the air infiltration of whole dwellings directly on site has been developed and is described.

The apparatus is a potential analytical tool for studying the effect of various individual leakage sources and for comparing one dwelling with another. Results for two houses are given.

The test method could form the basis of a performance acceptance test for new dwellings with a view to saving energy through air leakage control.

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INTRODUCTION

Air leakage can be responsible for a considerable part of the heat loss from a house. The cost of this wastage increases as fuel costs rise. Also, if the thermal insulation of a building is improved, air leakage will then account for a larger proportion of the remaining heat loss. Air leakage occurs through doors, windows, etc.

Most measurements of rates of air change in houses have been made by direct observations of a tracer gas under prevailing conditions. Little is known of the intrinsic airtightness of houses, or the distribution of the main sources of leakage.

Individual components such as doors and windows can be laboratory tested to measure their air leakage for a range of air pressure differentials. It then becomes feasible to relate from specific conditions through the pressure differential so created to the air leakage through the component. This report describes the use of an apparatus that enables the air leakage characteristics of a whole house to be measured.

DESCRIPTION OF TEST EQUIPMENT

The principal assembly consists of a flow measurement duct and electric fan connected in series. A wooden leaf is placed in an exterior doorway of the house to be tested. The fan unit is then mounted in this leaf (see Fig 1 and Plate 1). The original door of the house may remain on its hinges provided it can be opened to 80°.

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The speed of the fan can be regulated by means of a variable transformer in the electrical supply.

Air is driven via the duct and fan either into or out of the house so as to set up a known régime of pressure differentials between the interior and the outside. The air flow is measured by means of a propeller anemometer mounted in the centre of the duct.

The air flow is reversed by reversing the fan/duct assembly in the leaf. Hence the anemometer remains upstream of the fan at all times.

The apparatus was calibrated for air flow measurement, and it is preferable that any similar apparatus also be individually calibrated. It is possible, however, that a fairly exact copy of the apparatus (see Fig 5) will give reasonable estimates of air flow, suitable for comparative assessments, on the basis of the calibration given here (Fig 2).

The calibration was done by arranging for the unit to extract air from the pressure test box of a BS 4315 rig[1]. The fan and duct unit was run at such a speed as to maintain the box at atmospheric pressure, as indicated by the manometer on the rig. The unit was then acting against zero back pressure. Under these conditions air was supplied at various measured flow rates and the corresponding anemometer readings were noted. This was done with the fan and duct unit working against a series of back pressures up to 150 N/m^2. The anemometer reading depended on the back pressure, especially at low flow rates. This was attributed to various influences from the fan - swirl, uneven flow pattern and centrifugal effects - all working back upstream to the anemometer despite the straightening honeycomb (see Fig 1).

An extra item is inserted into the duct for the measurement of low flow rates. This is an assembly of a resistance mesh and orifice plate with a honeycomb flow straightener in the orifice. It is inserted between the anemometer and the fan (low flow insert - see Fig 1). The purpose of this insert is to avoid the need for high back pressure corrections at low flow rates. Though effective, the insert also reduces the maximum flow.

A large polythene bag was constructed to extend the air flow calibration beyond the 1150 m^3/h capacity of the measured air supply. The time taken to fill this bag using the fan/duct assembly was compared with the time using a measured flow from the weathertest rig (see Plate 2). The calibration points so obtained were consistent with the straight line (on log v log paper) established for flows below 1150 m^3/h. If the measured air supply available for calibration is less than in this case it may be possible to extend calibration by the bag method further down the range.

The calibration plots from which air flow may be estimated from readings of anemometer speed are given in Fig 2. The low flow range applies when the low flow insert (described above) is fitted.

TEST PROCEDURE

The exterior door of the dwelling is placed in the wide open position and the apparatus is inserted in the doorway. The edges are sealed with adhesive tape.

A liquid-filled inclined manometer is set up to measure the pressure difference between the inside of the building and the outside.

The fan is set running and the speed adjusted to give a steady 10 N/m^2 pressure difference. The anemometer speed is then noted. This is repeated at 30 N/m^2 and at increments of 20 N/m^2, for example, thereafter.

The fan/duct unit and the manometer connections are then reversed. The procedure is repeated with the pressure difference acting in the opposite sense.

A plot can be made of air flow against pressure to characterise the leakage of the building as it was at the time of test. The plot is generally of smooth "S"- like form (see Fig 3 and 4).

Tests under windy conditions should be avoided if possible. Even moderate winds may make it difficult to maintain a steady pressure difference. With pressure surges of less than $\pm$ 5 N/m^2 an estimated mean value can be taken and a smooth curve is still obtained. It may be advisable to protect the intake duct from cross winds by erecting temporary screens. These should be kept at least a metre from the intake to avoid impeding the flow.

DISCUSSION

The apparatus is readily portable and can be taken to site by van and installed and operated by two people. It is possible to test furnished occupied dwellings without damage to furniture or decoration.

Figures 3 and 4 show air-leakage curves for an ordinary semi-detached house and an experimental house respectively. No allowance has been made for the leakage of the exterior door replaced by the test apparatus (about 200 m^3/h at 50 N/m^2). An excess of exterior pressure over interior is taken as a positive differential to accord with the convention established by BS 4315 on components.

By using self-adhesive tape to seal various leakage sources their contribution to total leakage can be assessed.

The bar charts in Figs 3 and 4 show the contributions of various leakage sources under test estimated from leakage curves at a pressure of 50 N/m^2.

A surprising feature of the results is the small proportion of total leakage that is accounted for by the door and windows of the ordinary house. These were of normal timber construction and not fitted with weatherstrips.

The windows of the experimental dwelling, which was intended to be particularly airtight, were fitted with flexible seals and two back doors in series were used. The small contribution from doors and windows is not therefore surprising. The large contribution from the ground floor is attributable to this being of suspended type and to the crawl space, giving under floor access to technicians, being open to atmosphere at the time of test. The large contribution from the stack pipe casing was due mainly to an oversize irregular hole where the pipe passed into the loft. Tests with a smoke tracer showed that part of the leakage still unaccounted for was via a multitude of cracks at panel joints and between the frames of doors and windows and the walls surrounding them.

The apparatus may be used to compare one building with another in terms of their propensity to leak air or to monitor the progress of operations aimed at reducing air leakage in a particular house.

It should be possible to postulate attainable levels for new construction when enough houses have been tested to establish existing levels of leakage.

The method might be used as a performance acceptance test for new dwellings.

The air leakage as determined by this method cannot yet be directly related to ventilation rates and energy usage. This should be possible in due course by using the method on dwellings where these other aspects have been monitored.

CONCLUSIONS

1 An easily portable apparatus has been developed for measuring the air leakage characteristics of whole dwellings.

2 The new apparatus will make it possible to compare the airtightness of one dwelling with another.

3 The apparatus enables the effect of various leakage sources on total air leakage to be studied.

4 The technique could be made the basis of a performance acceptance test for new dwellings with a view to conserving energy.

REFERENCE

1 BS 4315:Part 1:1968 Methods of test for resistance to air and water penetration.

Plate 1 THE APPARATUS MOUNTED IN A HOUSE DOORWAY

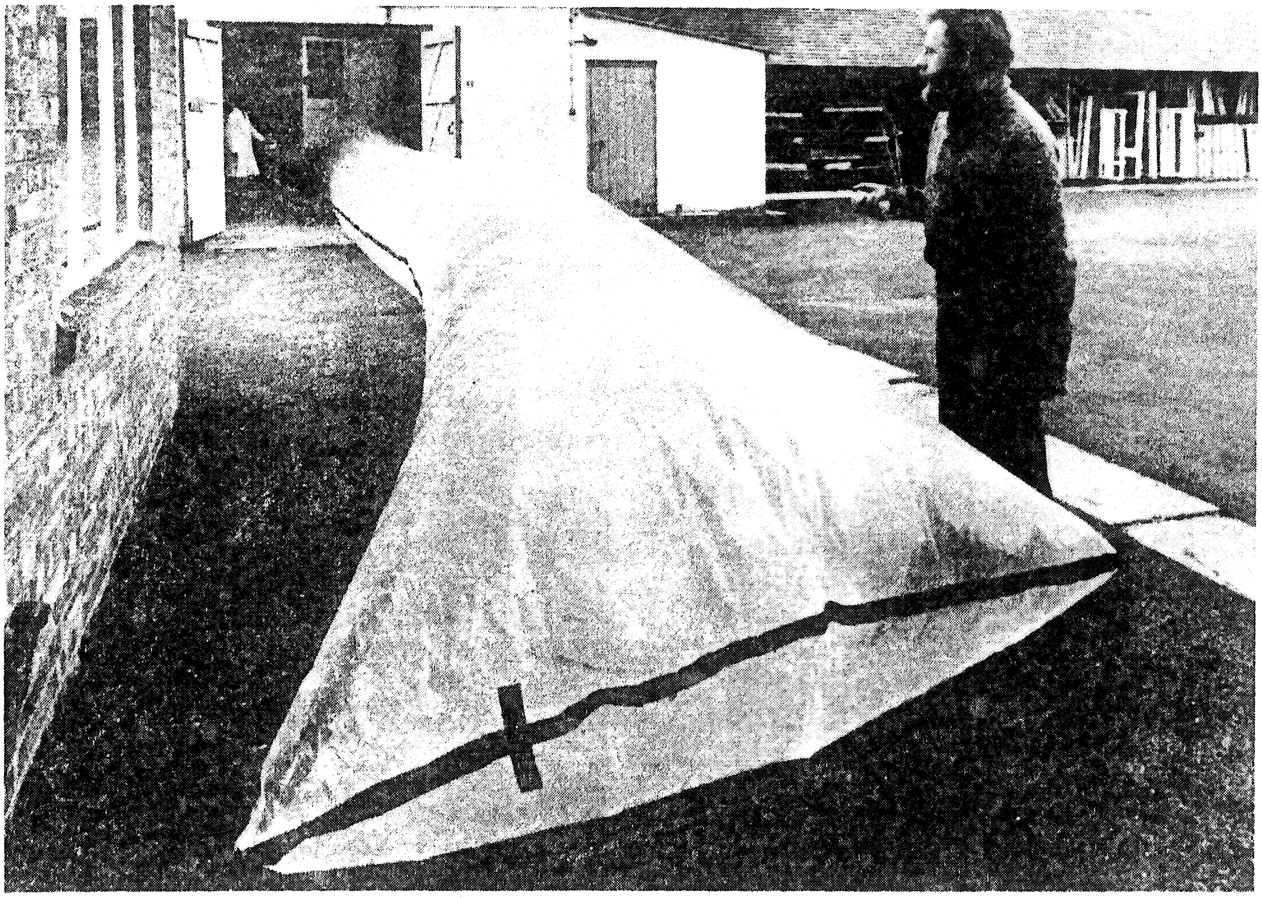

Plate 2 CALIBRATING THE APPARATUS USING A BAG

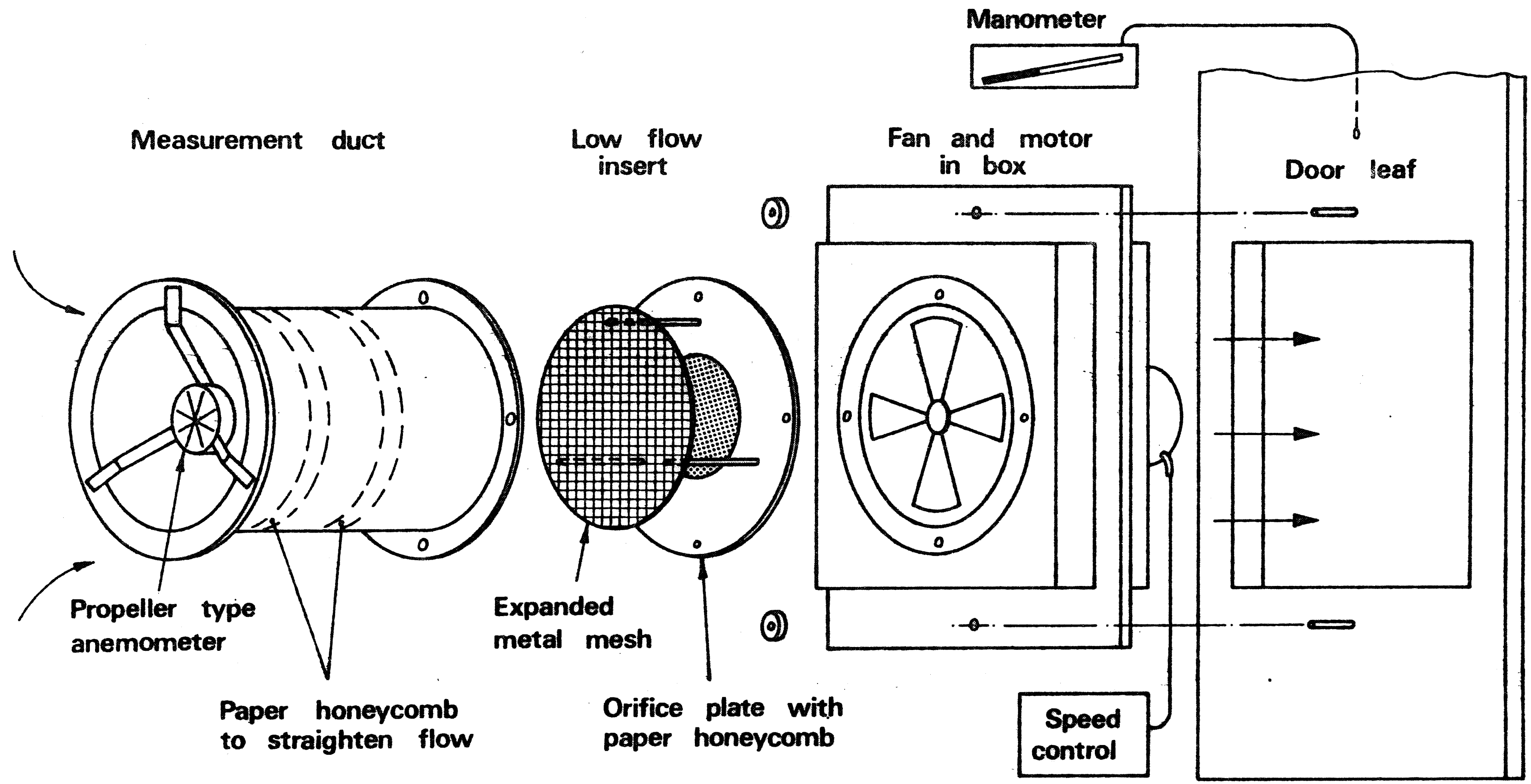

Fig. 1. Portable air leakage apparatus

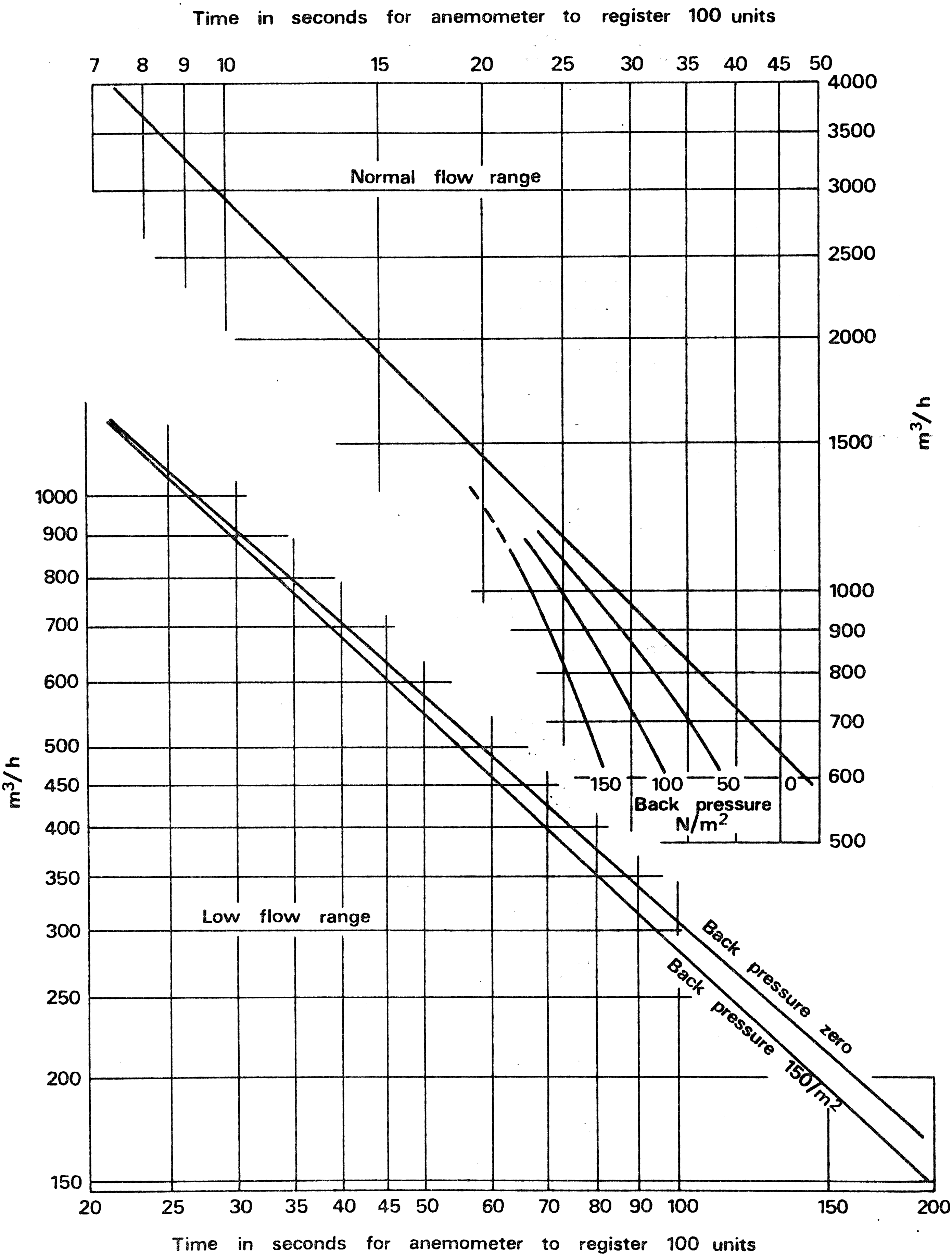

Fig. 2. Air flow calibration

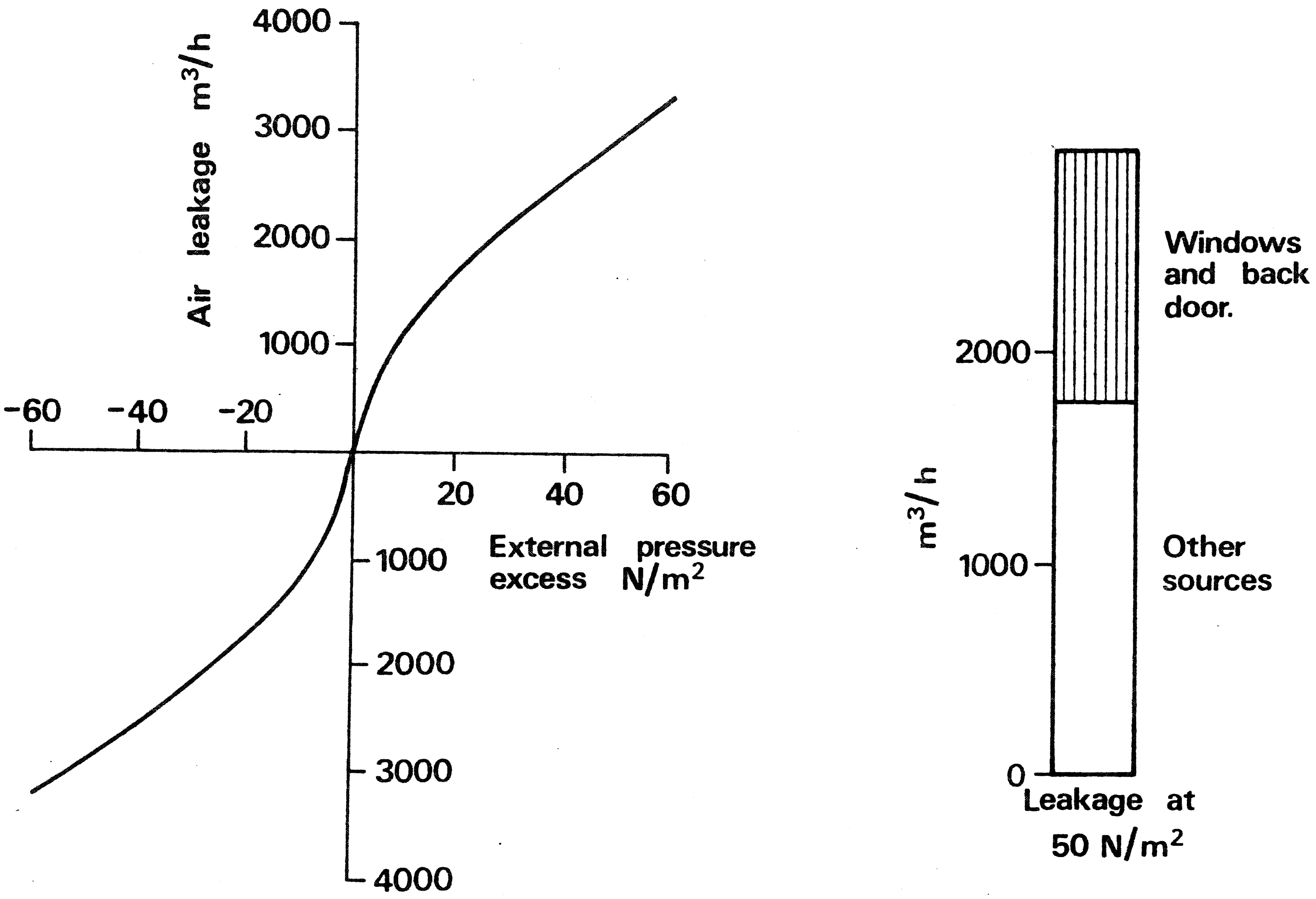

Fig. 3. Air leakage on semi - detached house

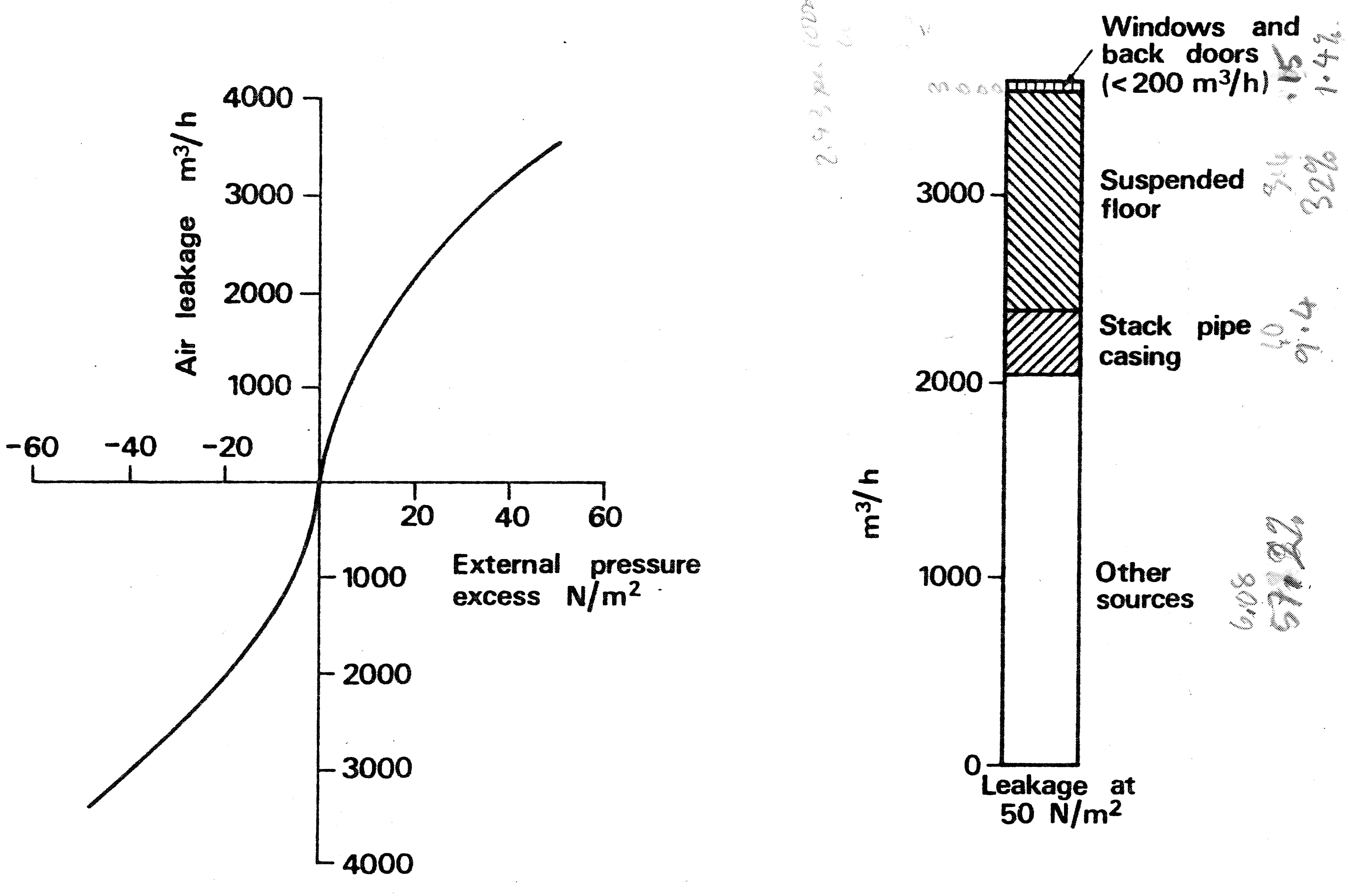

Fig. 4. Air leakage on experimental house

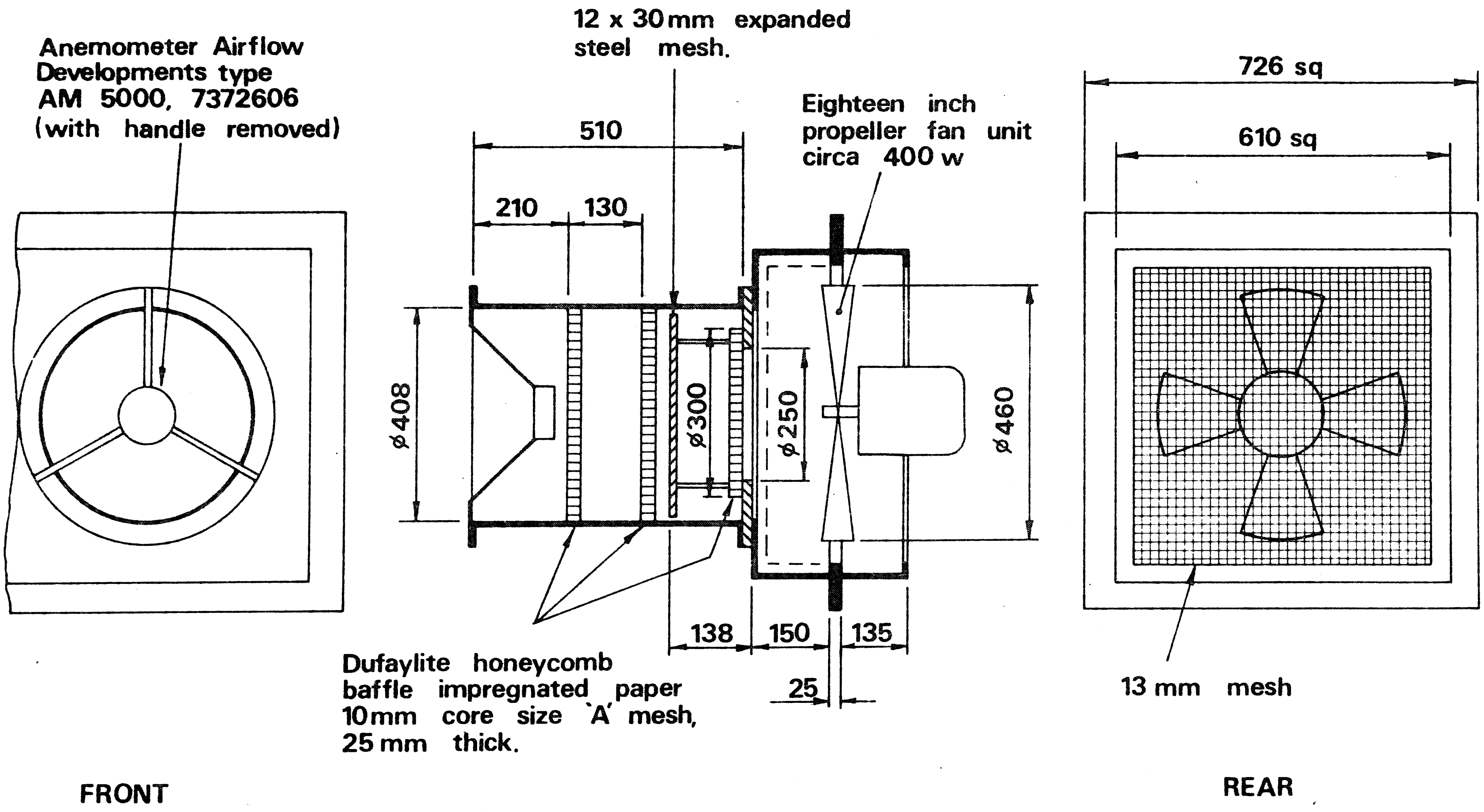

Fig. 5. Detail drawing of air leakage apparatus