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BUILDING RESEARCH ASSOCIATION OF NEW ZEALAND

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PROSPECTS FOR DOMESTIC ENERGY CONSERVATION IN NEW ZEALAND

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1. Introduction

This paper aims to identify proper targets for energy conservation measures in domestic buildings and proposes a program for their implementation.

The paper offers an outline of the energy flow pattern which is typical for domestic buildings, comments on the possibilities which might exist for conservation in various items, and briefly outlines a new simple method by which building design can be optimised to reduce heating energy needs.

2. Thermal Insulation

The value and importance of thermal insulation in energy conservation has now become well recognised. However, action is necessarily relatively slow. We illustrate in Fig.1 the degree of success in getting dwellings insulated. Whilst considerable progress has been made on the insulation of roofs, there is a good way still to go. Prior to mandatory insulation, very few dwellings were receiving the wrap-around insulation (roofs, walls, and floors) which is now known to be needed for maximum effect.

However, Fig.1 does not indicate the quality of insulation achieved, nor does it show that a large part of the progress on insulation was being made on existing, not new, dwellings.

3. Energy Use in Domestic Buildings

An important first step in determining an energy conservation strategy is to develop a sound understanding of exactly where the energy goes to in typical situations. A representation of the pattern of the energy flows in domestic buildings, as currently understood, is illustrated in Fig.2. It is not a simple matter to reliably construct such information, particularly because some energy use in fact doubles for more than one purpose, and partly because an appreciable part of heating energy is provided by the environment and cannot be metered directly.

Fig.2 illustrates typical electrical energy use distribution in domestic buildings. It shows that water heating is still the largest energy demand, closely followed by space heating. The demand for energy for other purposes - 'appliance energy' - is much smaller, although rather larger than was realised until relatively few years ago.

Appliance energy may be regarded as -

(a) relatively unimportant; and

(b) relatively uncontrollable.

It contributes directly and powerfully to our standard of living, providing such services as lighting, T.V., refrigeration, cooking. However, the "other" use of energy also provides a significant portion of space heating during the winter period. Almost all of the appliance energy used in winter in fact provides useful space heating. A similar effect is produced by the standing losses of hot water cylinders. Appliance energy usually contributes at least 10 KWh daily to the space heating of an average domestic building. A further 6 KWh daily is typically provided by body heat release from occupants.

Additional space heating energy is provided by sunshine, the quantity being dependent on the planning of the building and on how effectively autumn pruning is maintained, but can easily exceed the casual internal heating. There is therefore quite an appreciable supply of space heating energy available fortuitously. The question to be asked then, is whether with reasonable and economic conservation measures, this fortuitous energy is enough to provide satisfactory winter heating with no more than minor supplementing from direct space heating.

4. The "Keyhole" Model

Investigation of the question posed above leads us to a feature which we have chosen to call the "keyhole" phenomenon. The "Keyhole" is illustrated in Fig.3, and discussed below. It represents the magnitude to which the overall heat conductance of a house must be reduced to avoid any significant need for space heating.

In Fig.3 we see the predicted effects of a progressive schedule of thermal insulation. The vertical length of the bars represents the amount of heating energy needed in a year, on the right is shown the "Keyhole", i.e. the size of heat requirement which can be satisfied without heating. The left-hand example is for an uninsulated house. Those further to the right show the effects of insulating roof, wall and floor in that order, to the level now required in NZS 4218P. It is clear that although roof insulation is the most effective single measure, a substantial part of the heating requirement remains if roof-only insulation is used. It is also clear that no amount of improvement to roof, wall and floor insulation will reduce the energy needs to the size of the "Keyhole". On the other hand, it may seem that if the losses from windows and ventilation are moderately reduce, the "Keyhole" may be achieved without any further increase in insulation levels.

5. Ventilation Heat Recovery

There has been a long-term trend for our buildings to have less air leakage than they once did. This is a desirable trend from the point of view of energy conservation.

However, it may bring its own problems. In some cases, the degree of air tightness may be sufficient to encourage indoor surface mildew or moisture condensation problems. It is not feasible to engineer buildings to have just the right amount of air leakage, and in any case, the right amount changes with time.

The logical approach is therefore to encourage the present trends towards low-leakage buildings, and then to add mechanical ventilation. In these circumstances, one must utilise heat recovery processes, so that the actual ventilation rate may be maintained as high as 3 or 4 air changes per hour, but the energy cost limited to that of less than 1 air change/hour.

6. Design and Planning - the ALF method

One of the most effective and potentially cheapest methods of reducing space heating requirements is to optimise building planning to make maximum use of available sunshine. Some methods of doing this were well known last century.

One difficulty in so optimising building design has been the lack of adequate design or assessment tools to provide the right sort of guidance. This lack has made it far too easy for false targets to be chosen. Modern computer assessment can produce reliable energy analyses (provided that the building erected is in fact the one the computer was told to analyse), but this is not a practical method for individual dwellings.

However, a new method of hand calculation, designated the ALF method (Annual Loss Factor Method), has now been adapted from Canada to New Zealand's climatic conditions. Although itself a pad and pencil exercise, the ALF method is actually a computer-aided design process. The method is expected to actively promote energy-saving home design, by guiding the willing designer into the correct design choices (of window location, sizing, orientation, etc.). Its greatest virtue is that it is suitable for use by any interested designer or builder, thus making specific thermal design a reality.

7. Domestic Hot Water

Although it is generally known that hot water service is a large energy user, it is not widely appreciated how much of this energy is dissipated in standing losses - typically one third of the input.

Hot water cylinders have been manufactured to reasonably good insulation standards for many years, but it has been clearly shown that better insulation is now appropriate. The New Zealand Standard is being re-examined. On the other hand, (and not at all obvious) is the fact that for many domestic hot water pipes, energy losses would be reduced if they were not insulated. Those where pipe insulation does help (principally to kitchen sink) the quality normally provided is so far short of that necessary that it isn't worth the effort. Far greater rewards are likely from better engineered piping systems, and it is here that research effort should be directed.

The use of solar energy to contribute to water heating is a well-known technology now. It can contribute about half of the hot water energy needs.

The prospects for heat recovery from waste water have not been examined very deeply at this stage. Contributing to this situation were the assumed technical difficulties of developing equipment which would continue to function reliably without maintenance, and also the general fear that plumbing regulations would be too inflexible to permit its use anyway. However, neither problem now seems insuperable, and at least one possible method has been given preliminary examination. Work so far suggests that between 25% and 50% of the waste energy should be recoverable. More research will be required to demonstrate the practicality of such systems.

The use of heat recovery techniques may therefore provide nearly as much energy as good solar collecting systems, but they would have one important advantage. Energy savings would not be dependent on the weather, and hence they would offer a genuine and reliable reduction in demand to electricity supply authorities. Further, their usefulness will be increased rather than reduced in winter, and will also increase roughly proportional with demand.

8. Construction Energy

Energy is required to manufacture materials and to transport them and construction labour to construction sites. Various overseas attempts to estimate these energy requirements in the past have indicated construction energy to be fairly small compared with the operating energy required after occupation. Typically, construction energy has been estimated at 2-8 years operating energy.

A recent comprehensive study (see Ref 7) in the USA has indicated that previous estimates of construction were too low. This conclusion has also been reached in a recent rather simplified estimate carried out at BRANZ, based on several NZERDC energy-use reports on New Zealand industry. Together with the lower heating energy use here, the estimated average construction energy for houses in New Zealand becomes equal to about 10 years operating energy requirements. However, unless the life of these buildings is less than 30 or 40 years, the construction energy remains of much less concern than the operating energy.

There are appreciable differences in the construction energy requirements of different material systems. Generally, timber is a low-energy material, but processed timber (as particle board, fibre boards, paper products) have much higher energy requirements, as do many metals, ceramics and glass.

9. Conclusions

Significant energy conservation in domestic buildings is technically and economically feasible.

> Space heating could be reduced to an unimportant energy load by proper attention to :
>
> Thermal insulation
> Air leakage
> Improved building planning.
>
> Thermal insulation will not achieve this goal alone, but need not be required at higher standards than now set. Development work on ventilation heat recovery is needed. New assessment tools, such as the 'ALF' method are now becoming available.
>
> Hot water service energy requirements can be reduced by better cylinder insulation and piping systems. There are good prospects for waste heat recovery, and investigation should proceed.

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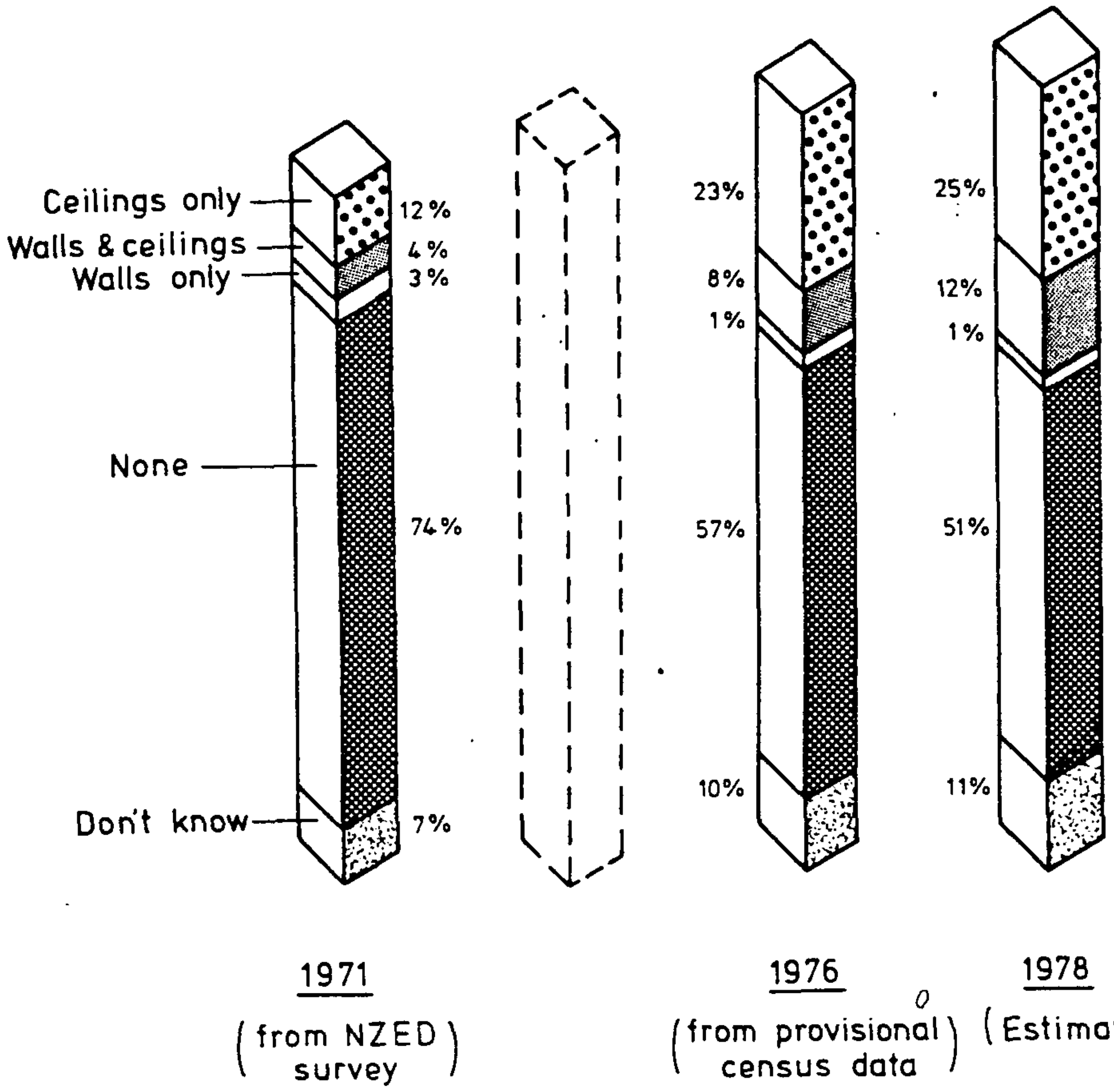

FIG.1 PROPORTION OF N.Z. DWELLINGS INSULATED AT DATE INDICATED

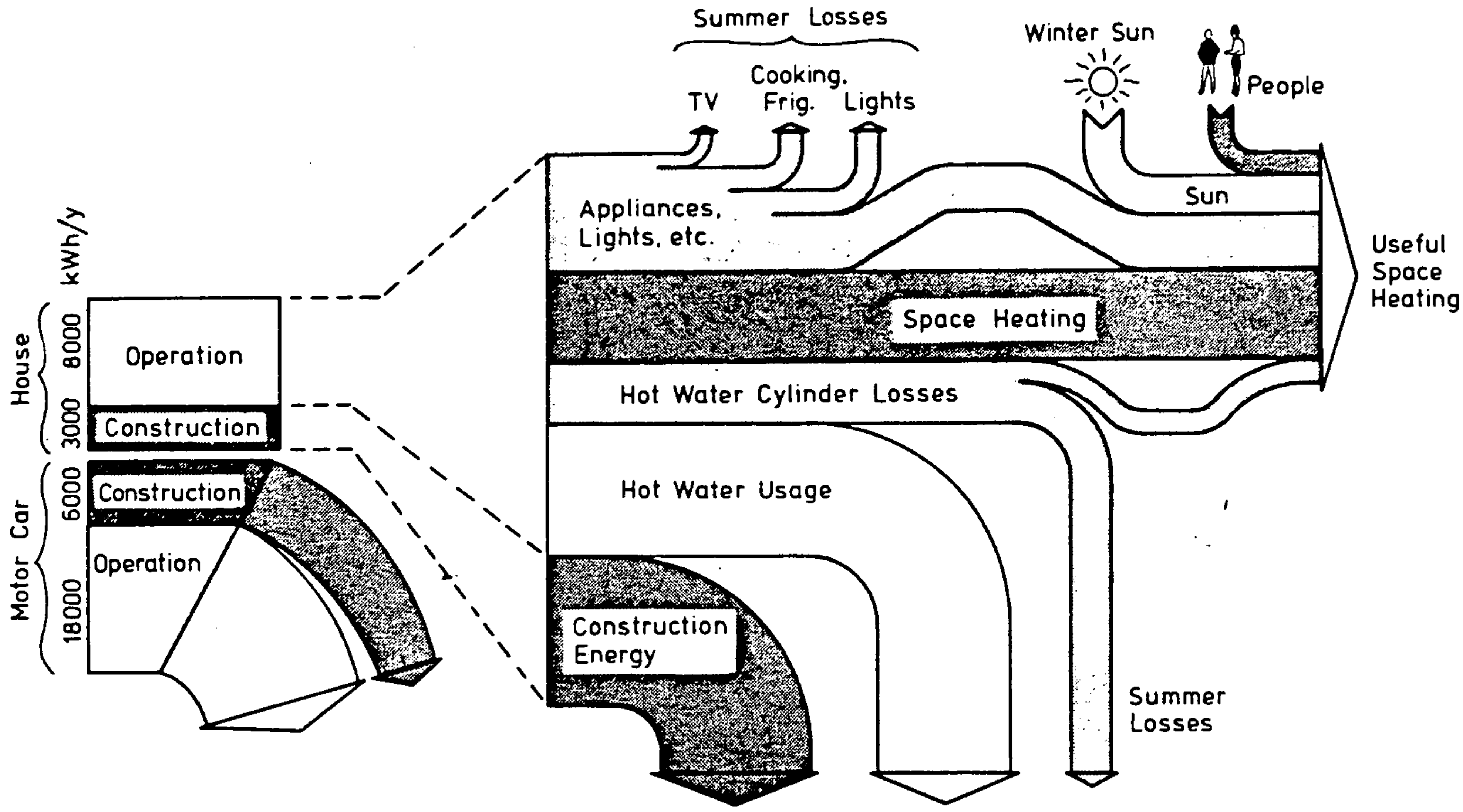

FIG. 2 DISTRIBUTION OF USE OF ENERGY IN HOUSES

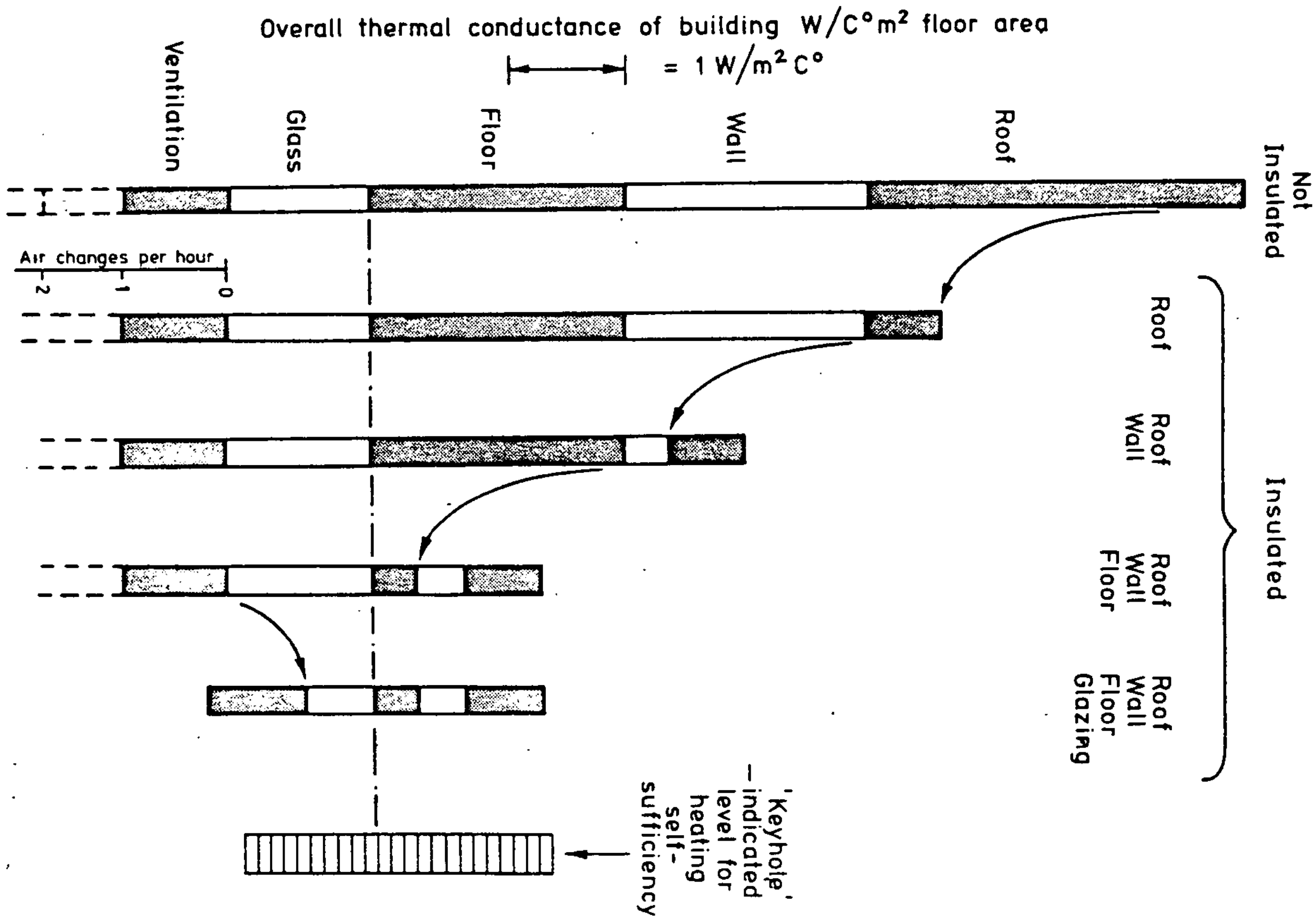

FIG. 3 ILLUSTRATING THE 'KEYHOLE' EFFECT AND THE EFFECT OF A PROGRESSIVE INSULATION PROGRAM