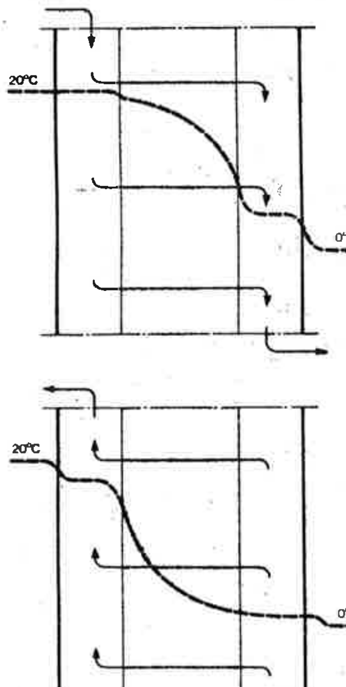
Dynamic insulation: the next step?

Dynamic insulation can reduce heating bills for buildings almost to zero. This article, reprinted with kind permission from* Building Services *(UK), February 1984, looks at research and experience in Sweden and France, where the technique is being taken seriously.

Dynamic insulation is a means of reducing building heat losses to near zero without the use of massive thermal insulation. It relies on re-cycling the heat conducted through the fabric or reducing the temperature gradient by means of a suitable heat transport fluid — usually air and sometimes water.

Most progress so far has been made in Sweden where a number of dynamically-insulated structures have been built, and in France where the performance of two prototype structures is being evaluated.

Heat conducted through a structural element such as a wall or roof can be treated or recycled in various ways. In its simplest form the heat transfer air passes through a structural cavity on the cold outside face of the insulation, exchanging heat with it. The air can be either fresh air from outside — in which case it is pre-heated by the insulation, or exhaust air from the room — in which case it is cooled before leaving the cavity, its action in this case being to reduce the temperature gradient through the insulation and therefore retard the loss. French research workers describe this as the *parieto-dynamic* (Latin: pariet = wall) system.



Heat and air flow patterns in the dynamic insulation system.

A more advanced form, and the one most widely used at the moment, is where the heat transfer air passes directly through the layer of structural insulation itself (glass fibre blanket or similar) — the *permeo-dynamic* system.

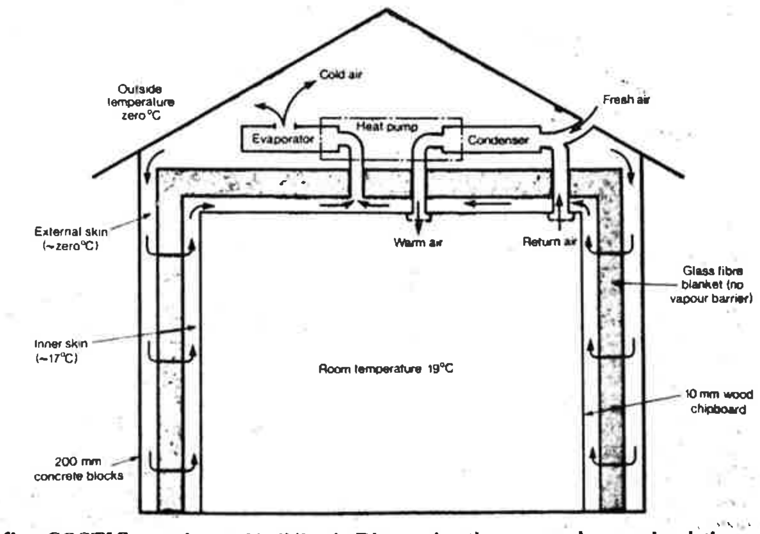
In this system the air flow direction can be either contra or parallel flow. In the contra-flow regime the gradient across the insulation is reduced at the cold outer surface but becomes steeper at the room side, signifying a reduction of losses but an increase in the re-cycled heat. The temperature profile becomes exponential.

Most of the field experience with dynamic insulation has been gained in Sweden where the applications have been mostly in roofs of single storey sheeted structures. Because mechanical ventilation is now mandatory in Sweden, all these buildings use the contra-flow dynamic system to pre-heat the incoming air. Fans mounted at roof level pressurise the space between the roof sheeting and the mineral wool insulation underneath. The very low rates involved, corresponding to velocities of 1-5 m/h, mean that roof space pressure is low and air tightness not therefore a particularly important factor. In fact outward air leakage has been found to help prevent rain water entering joints between the sheets.

So far, some 80,000 m^2 of these contra-flow roofs have been installed in Sweden. The only problem reported is reverse flow of air into the roof when fans are stopped during the summer, causing dust deposition. One solution adopted is to run the fans at low speed, just sufficient to prevent back flow. In the housing sector in Sweden, dynamic insulation has been mostly limited to a few experimental installations.

Research on dynamic insulation in France goes back now about eight years, the first prototype experimental building being completed in 1978, and a second — with improved design and more extensive instrumentation — built in 1981 and commissioned late 1982. Although open circuit fresh air systems based on the permeo-dynamic principle were at first investigated, current research is now based entirely on closed circuit operation using a heat pump to recover the heat "lost" from the walls and roof. The main reason for dropping work on open circuit systems was the risk of contamination from radon, formaldehyde and other substances: the reasoning was that the forced air flow would promote higher contaminant release.

The first building is a single storey structure with 176m^2 floor area containing offices and a lecture room. It has a 100 mm thick glass fibre quilt dividing the wall cavity into two air channels. The normal heat loss of this building, including air change, was calculated as 0.96 W/m^{3}K. Air passes in contra-flow through the insulation at a velocity of 1-2 m/h and forms a closed circuit with the heat pump evaporator. The condenser is used to heat the fresh/recirculated air supply. Nominal rating of the heat pump is 3.4 kW and total air flow rate over the evaporator 300 m^3/h. An energy balance for the first two winter months of 1981 gave an apparent heat loss of 0.3 W/m^{3}K. Variation over the season was 0.2 to 0.6 W/m^{3}K.



The first COSTIC experimental building in Digne using the permeo-dynamic insulation system combined with a heat pump. Air passes in contra-flow through the glass fibre insulation and forms a closed circuit with the heat pump evaporator.