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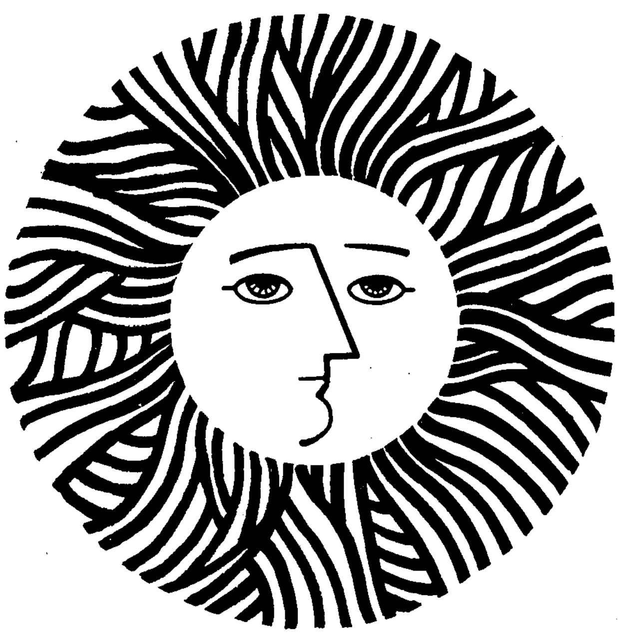

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MULTIPLE GLAZING SYSTEMS WITH BETWEEN PANES VENTILATION

Introduction

The Energy Efficient Windows Program at Lawrence Berkeley Laboratory, under funding by the Department of Energy, is engaged in research, development, and demonstration activities directed toward improving the thermal performance of windows. The program includes support of the development of new window technologies, as well as advancing the body of knowledge for the improved application of existing products and established design techniques.

Glass, because of its high thermal conductance relative to other building envelope components, has been identified as a singularly high contributor to overall building energy consumption. It has been estimated that windows account for 25% of the annual building consumption of energy in this country. Building energy consumption has been estimated at 20% of the nation's total. Thus windows would account for 5% of the total. The obvious shortcomings of windows as thermal barriers has brought about a widespread effort to substantially reduce the area of windows and in some cases even total elimination. While this may be a viable logic in some instances, there are other options that seek to minimize negative qualities and to maximize the potential benefits, such as solar gain and daylighting, of windows. Through proper design and application window energy consumption can be significantly reduced and may even provide a net energy benefit.

Among the options being investigated in the LBL Windows program is a type of window that utilizes air flow between multiple panes of glazing. Testing programs for two different basic types are being supported at the University of Arizona/Environmental Research Laboratory and at the University of Utah. These programs include field testing during the 1979-1980 winter season and the 1980 summer season. Final reports will be completed in the latter part of 1980. LBL technical management is under the direction of Stephen Selkowitz and Richard Johnson.

Static Insulation of Windows

In order to reduce thermal transmission through windows it has been common practice to form an insulating air space between two panes of glass which are then sealed at the perimeter. This effectively reduces conductive/convective transmission to approximately half but results in only a minor change in radiant energy transfer. It thus continues to be necessary to use conventional methods of shading and solar control devices to mitigate unwanted solar gain, to modulate light and to afford privacy. In addition, perimeter heating and cooling may continue to be necessary in order to maintain thermal comfort in the vicinity of the window.

Dynamic Control with Heat and Mass Transfer

In order to obtain additional dimensions of energy transfer control within the window system some workers have incorporated venetian blinds between the panes of glass and intentionally introduced air flow through the cavity. Thus, rather than approaching the window as a static insulator which is inherentally contradictory, the window is operated as a dynamic heat exchanger. The venetian blind can be deployed to either intercept solar radiant energy or allow its direct transmission. Closure at night impedes the transfer of long wave infra-red radiation. Air passing through the cavity acts as an agent to transfer thermal energy as required.

Variations on the venetian blind include two tone blades with one side being light colored and highly reflective and the other side being dark colored and absorptive. The extreme of this combination is polished metallic on one side and matt black on the other. Solar radiation is thus either reflected from or absorbed by the blind.

During the overheated period, heat is collected within the cavity through the normal gain mechanisms and is rejected to the exterior by ventilation. During the heating season the solar heated air is distributed into the building. By direct communication of room air with the cavity the mean radiant temperature of the interior surface of the interior window pane may more closely approximate room temperature, thereby improving thermal comfort in the vicinity of the window.

The Clearview Solar Collector Window

One such system, which is assembled from off the shelf components conventionally used in residential construction, has been devised by workers at the Environmental Research Laboratory at the University of Arizona. This consists of pairs of single glazed, aluminum framed, sliding glass doors or windows. Two units are installed in parallel forming an air cavity between which is fitted with a venetian blind. With the second glazing unit installed in its own framing system outside the conventional exterior wall it is called the Clearview Solar Collector Window. Another configuration, called the Klos Window, combines two identical windows in a common framed opening and is shown in Fig. 1.

Summer cooling in the hot dry Arizona climate is easily achieved with evaporative coolers. The venetian blinds are positioned to reject solar radiation and the windows are cracked open, the inside

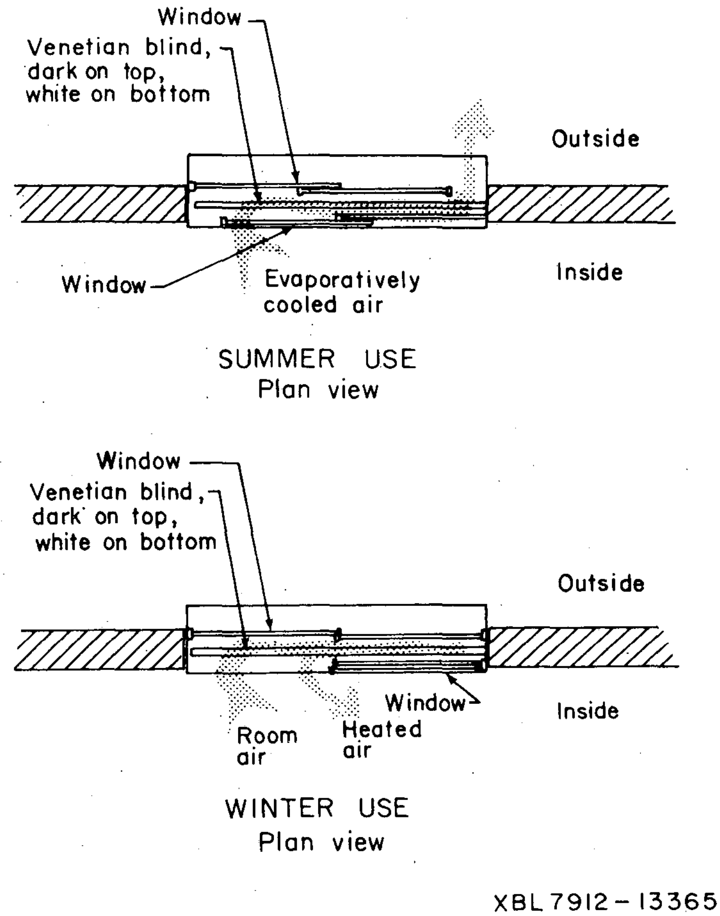

Figure 1.

window being opened on one end and the outside being opened on the opposite. The room overpressurization produced by the cooler causes air to exhaust through the window cavity rejecting heat to the exterior.

Winter heating is achieved in a more direct fashion by using the window as a solar collector. The blinds are positioned to absorb solar radiation. The outside window is closed and the inside window is opened. At night the blind and the window are closed in order to reduce losses. A small fan can be added to improve air distribution during the solar collection mode.

The simplicity, directness, and utilization of low-cost, readily available components lends considerable promise for application in both retrofit and new residential construction. Preliminary testing has demonstrated system effectiveness. LBL/DOE is presently supporting additional testing at ERL under the direction of John Peck. A demonstration window has been installed in the ERL Building in Tucson, Arizona. It will be instrumented and data collected during actual winter and summer conditions. Data collection procedures are being designed in order to be able to computer model performance over the entire year for this climate. Through extrapolation, performance can then be modeled for other climates utilizing presently available handbook data. It is anticipated that test results will establish performance data that will stimulate widespread application in this climate. In addition, other climates for which this application would be beneficial will be identified.

The Exhaust Air Window

Another approach which incorporates windows engineered specifically for the application has been in use in Europe for several years. The system has been variously called extract air window and exhaust air window, and patents were taken out in Sweden in 1956. Windows are constructed with cavity ventilating ports for the passage of air at controlled rates which are induced by HVAC system pressures. Because of the intimate integration into the HVAC system the maximum benefits are most likely to be realized when designed into new construction.

Overall heat transfer co-efficients between room side and exterior are reported to be less than 0.1 BTU/hr/ft^2/°F. Shading co-efficients are reported to be less than 0.2. These values are variables dependent on air flow rates through the window cavity as indicated by Figure 2 and Figure 3. While this is very promising for improved thermal control

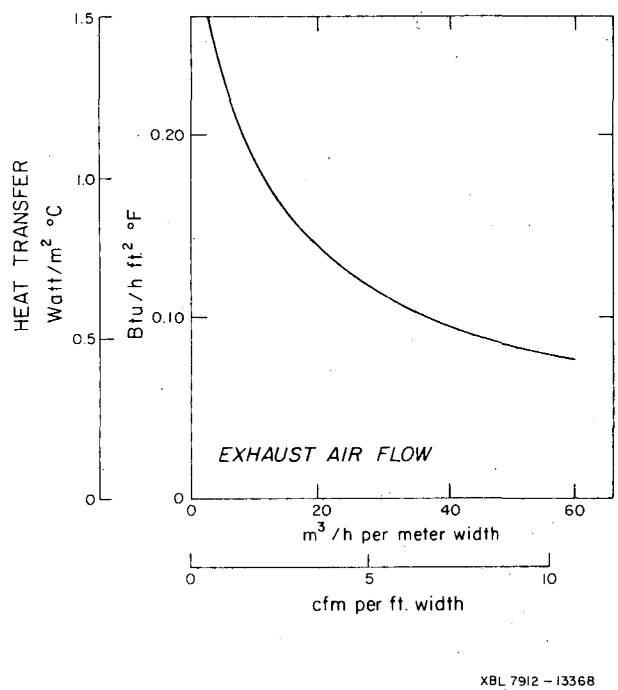

Figure 2.

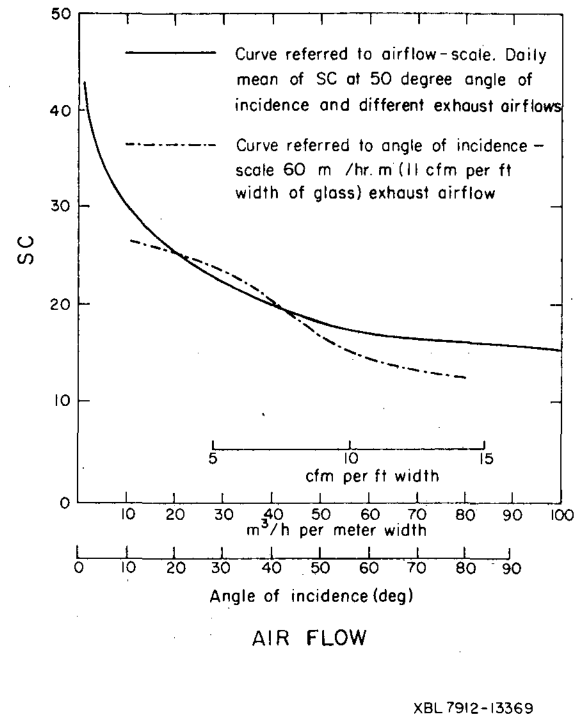

Figure 3.

within rooms with exterior glazing, net benefits have to be evaluated in terms of HVAC system efficiencies and costs.

The several variations which presently exist can be generally categorized into open systems and closed systems. In the open system a controlled amount of room air is exhausted through the window to the atmosphere. This loss is balanced with make up air in the supply system. Its characteristics seem to direct its application to buildings in which cooling is typically required to offset combined interior loads and solar gain.

In the closed loop system the window becomes an appendage to the return air duct. The return air duct is directly connected to the window ports and room air is first exhausted through the window and then into

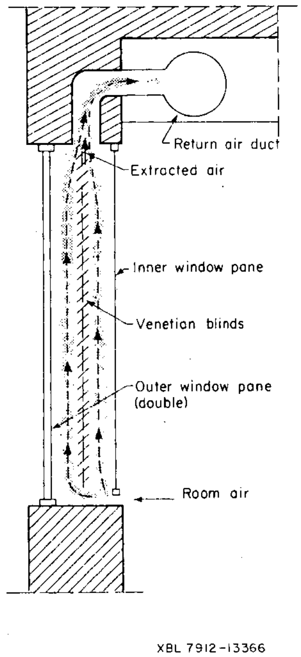

Figure 4.

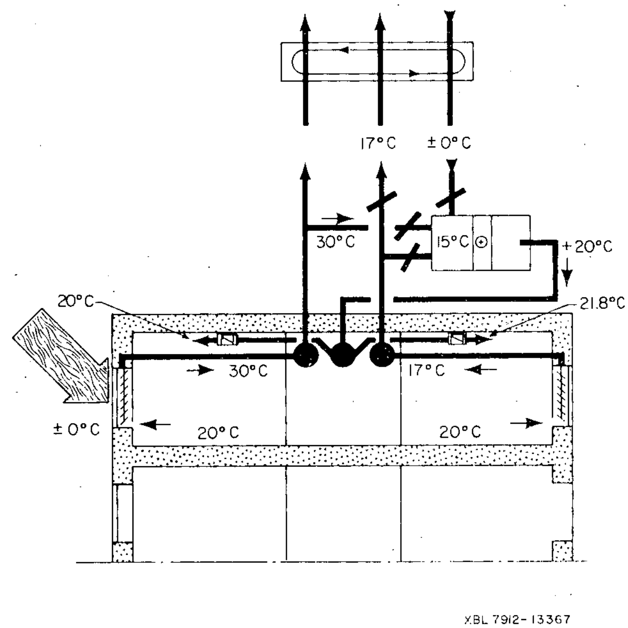

Figure 5.

the return air duct as indicated by the diagrammatic window section shown in Figure 4. This exhaust air may then be mixed with supply air or rejected to the atmosphere as indicated in the system schematic of Figure 5. This approach offers maximum control in both heating and cooling modes. Wanted heat gain can be collected and either redistributed or stored. Unwanted heat can be rejected to the atmosphere. Tempered room air on both sides of the interior glazing pane results in improved thermal uniformity that reduces cold down drafts and increases the mean radiant temperature of the glass. Perimeter radiators can thus be eliminated and a satisfactory level of thermal comfort is achieved in all seasons.

These windows have been in use in Europe since about 1967.

Performance data and design data continue to grow as does the acceptance and popularity of the application. In order to better understand the system operation and to establish suitable performance data LBL/DOE is supporting full size field testing at the University of Utah. This program is under the co-direction of Professors Kurt Brandle, School of Architecture, and Robert Boehm, Department of Mechanical Engineering. A test building on a rotating base is being fitted with both exhaust air windows and with conventional multiple glazed insulating windows. Comparative performance data will be taken in various compass orientations and weather conditions. This data will be computer modeled for a full year operation and the commercial potential will be assessed. Based on preliminary analyses and the European experience, it is believed that this system can offer considerable advantages within the framework of current commercial/institutional high rise building design. Test results will help to verify the validity of that projection and stimulate interest in the U.S. building community.

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