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Chilled ceilings and beams

This month the cost and research departments of Mott Green Wall and Davis Langdon & Everest examine the costs and specification of chilled ceilings and beams in collaboration with specialists Trox and Halton.

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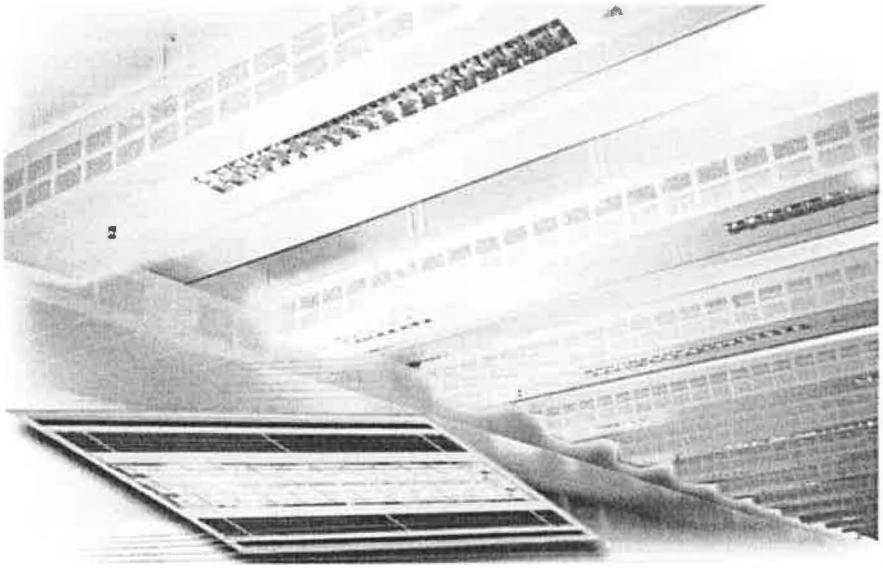
Mott Green & Wall specialises in the cost planning, procurement value engineering and cost management of building services installations.

Although the UK market for static cooling systems, either in the form of chilled ceilings or beams remains relatively small, the technique is gaining acceptance in a wider range of building types. During the 1990s, static cooling established a significant foothold in the owner-occupied office and office refurbishment sectors. More recently, chilled ceilings and beams have been specified for universities, IT and pharmaceutical companies, government buildings and retail developments. In the commercial office market, some major developers are now seriously considering static cooling as an option for speculative projects. However, to date, few projects have been completed for the letting market.



Advantages and disadvantages

The principal advantages of static cooling systems are as follows:

- the radiant cooling from chilled ceilings results in a low mean radiant room temperature, which leads to improved comfort conditions for occupants.
- improved comfort conditions also result from minimal draughts associated with all systems.
- a high quality fresh air supply is provided when static cooling is used in combination with a displacement ventilation system.
- energy consumption is reduced, primarily due to lower cooling loads and reduced airflows.
- maintenance requirements are low due to the simplicity of the installation in the office areas.
- static cooling systems have operating cost advantages of £7·9/m² NIA per annum, compared to fan coil units.
- ceiling void depths are reduced, particularly for chilled ceilings.
- noise levels are low.
- ceiling level electrical power for mechanical components is not required for either chilled ceilings or passive chilled beams.
- condensate pumps are not needed in the ceiling void.
- chilled ceilings are well suited to cellular office layouts.

Disadvantages of static cooling systems include:

- higher capital costs of chilled ceilings and passive chilled beams.
- requirements for a high performance facade to control solar load at the building perimeter.
- loss of net lettable area associated with the larger risers required for displacement ventilation used with chilled ceilings and chilled beams.
- requirements for office headroom in excess of 2·7 m to avoid air stratification.
- requirements for large chilled water flows, due to a typical waterside temperature drop across the coil of 2·3°C.
- requirements for dehumidification of the primary air supply via the cooling coil, to minimise the risk of condensation, necessitating the use of higher capacity air handling plant.

Comparison of static systems

This section provides an analysis of the principal features of chilled ceilings, passive and active chilled beams. Table 1 sets out a simple analysis of selection criteria for the three systems. Since chilled ceilings and passive chilled beams only provide cooling, separate heating and ventilation systems are also required. Low level perimeter heating systems are usually installed. Typically the specified ventilation system will either utilise high level supply and extract or low level displacement. Displacement ventilation is used in conjunction with 60-80% of chilled ceiling installations.

Active chilled beams combine cooling and ventilation functions into a single unit. Heating is also possible with this type of beam using either a changeover system or separate circuits controlled off four port valves.

Chilled ceilings provide unobtrusive, sensible cooling from a large overhead, cold surface, offsetting heat gains with both radiant and con-

vective cooling. The low mean radiant temperature associated with chilled ceilings allows the design room air temperature to be set 2-3°C above the general standard for air conditioned offices of 21-22°C, resulting in reduced overall cooling loads.

Passive chilled beams are typically specified to deal with cooling loads in excess of the 40-50 W/m² capacity of a chilled ceiling. These higher cooling loads are commonly associated with more densely occupied office space, high equipment loads or from high solar loads at the building perimeter. A passive chilled beam is a simple and effective cooling device comprising a cooling coil in a metal casing. Heat exchange in passive beams, occurs mainly by convection. Passive chilled beams are commonly recessed into ceiling voids above perforated tiles.

Active chilled beams achieve a higher cooling load of 80-150 W/m² due to the effectiveness of cooling using forced convention and induction. Forced convention occurs within the supply air plenum of the beam, while the relatively low static pressure caused by higher air velocities within the casing results in the induction of warm room air across the cooling coil.

A further development of the chilled beam concept is the multi-service beam. Most multi-service beams are bespoke products and it is difficult to provide representative generic cost information. Depending on cooling loads, services content and architectural concept, the supply only costs of multi-service beams range from £30/m² to £160/m².

Design issues

Condensation is a major concern in the design of static cooling systems, affecting maximum room temperatures, chilled water supply temperatures and requirements for dehumidification. A chilled ceiling is more likely to suffer condensation than a passive beam, which in turn is more at risk than an active chilled beam.

Chilled water supply temperature should be set at 14-15°C to avoid the risk of condensation. Relatively high chilled water temperatures permit the greater use of free cooling, when the external temperature drops below the chilled water supply temperature.

Chilled beam performance is optimised by keeping the water temperature differential between flow and return as low as possible. The flow and return differential between should be 3°C on an active chilled beam but could possibly be reduced to 2K on a passive beam with a low cooling capacity.

The typical maximum room temperature should be set at 24°C, compared to 21-22°C for conventional air conditioning systems. Maintaining a high temperature differential between chilled water and room design temperature is an important factor in achieving the required cooling output. A reduction of 1°C in the difference between room and mean water temperatures can reduce the cooling capacity of a chilled beam by up to 10%.

Additionally condensation prevention measure for active beams, requires that the primary air supply should be no more than 8°C below the maximum room design condition. In practice this defines a supply air temperature of 16°C, significantly above the standard for fan coil units of 12-13°C.

Condensation detection also needs to be incorporated into static cooling systems. If condensation is detected, the system can be programmed to either ramp up the chilled water supply temperature to ride above dew point, or to shut down the chilled water circuit.

Many of the advantages offered by static cooling systems are related to their inherent simplicity. Control systems should also be designed with simplicity in mind. Chilled beams and ceilings are ideally controlled in groups using two port, two position control valves. Valves can be pulse controlled to vary the length of time open in accordance with differences between measured room temperature and set point. Most systems now also have variable pump speed control so that a constant system pressure can be maintained as the system volume flow rate varies.

Although the controls associated with static cooling systems are relatively simple, the installations themselves have more sensors and valves than a conventional beams. As a result Category A beams costs are some 25% higher than an equivalent installation for fan coil units.

Cost comparison

The costs detailed in this model are based on analyses of recent office developments in London for owner occupier clients. The costs of a fan coil unit based scheme are also included for comparison.

Costs are current in second quarter 2001 based on a central London location.

The costs are representative of reasonable sized projects of 8000 m² to 20 000 m². Cost information provided by manufacturers suggests that economies of scale occur on large schemes in excess of 30 000m² gifa, and prices for static cooling installations may be lower than those set out in this model.

In order to allow a direct comparison between options, extra-over costs of suspended ceilings and raised floors associated with different systems are included in the Category A fit out costs.

Rates for the shell and core installation are given on the basis of gross floor area. Costs for the Category A fit out are given on the basis of the net internal area of treated office space.

TABLE 1: SYSTEM SELECTION CRITERIA

Element	Chilled ceiling/perimeter beam	Passive chilled beam	Active chilled beam
Cooling capacity (W/m² floor area)	80 (with perimeter beam) 40-50 (without perimeter beam)	80-120	80-150. Potential problem with draughts if exceeded
Ease of maintenance	Minimal - no moving parts	Minimal - limited for cleaning the coil of dust	Minimal - limited for cleaning the coil of dust
Layout flexibility	Good - large cooled surface area. Chilled elements are designed to fit into conventional ceiling tiles	Limited - beams must be positioned at particular spacings. Needs careful planning around grid lines	Limited - beams must be positioned at particular spacings. Needs careful planning around grid lines
Acoustics	Good - no moving parts. Possible noise from water flow in pipework attached to ceiling panels	Good - although may need to generate white noise to compensate for quiet operation	Good - although may need to generate white noise to compensate for quiet operation
Aesthetics	Good - ceiling tiles with chilled elements are indistinguishable from normal tiles	Featured, exposed beams are more aesthetically pleasing. If beam is in ceiling, grille may be different to ceiling tile	Featured, exposed beams are more aesthetically pleasing. If beam is in ceiling, grille may be different to ceiling tile
Comfort	Good - uniform coverage due to large numbers of active tiles	Air discharged downward, so less predictable air movement. May reduce output if above heat source	Good - predictable air movement patterns due to forced convection

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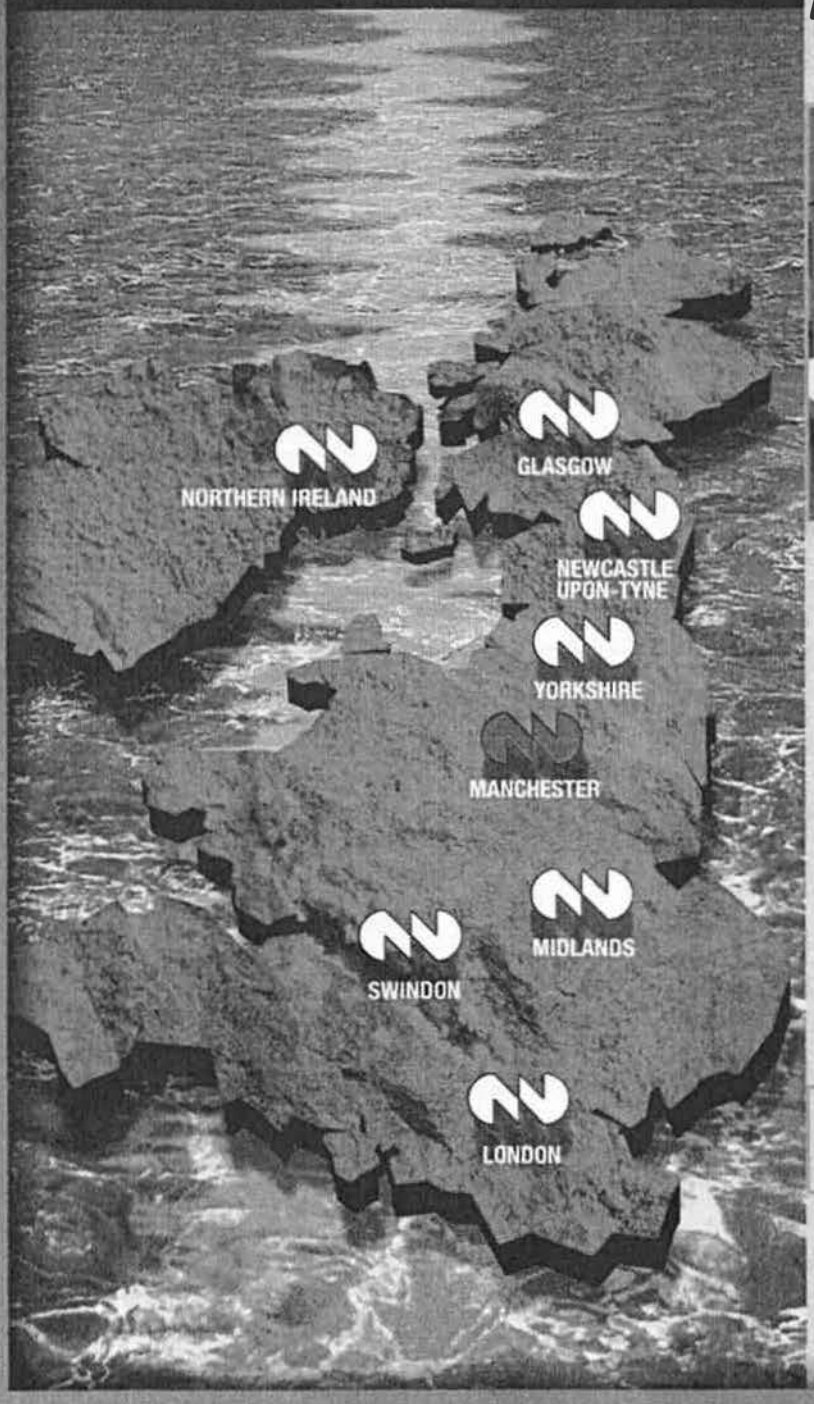

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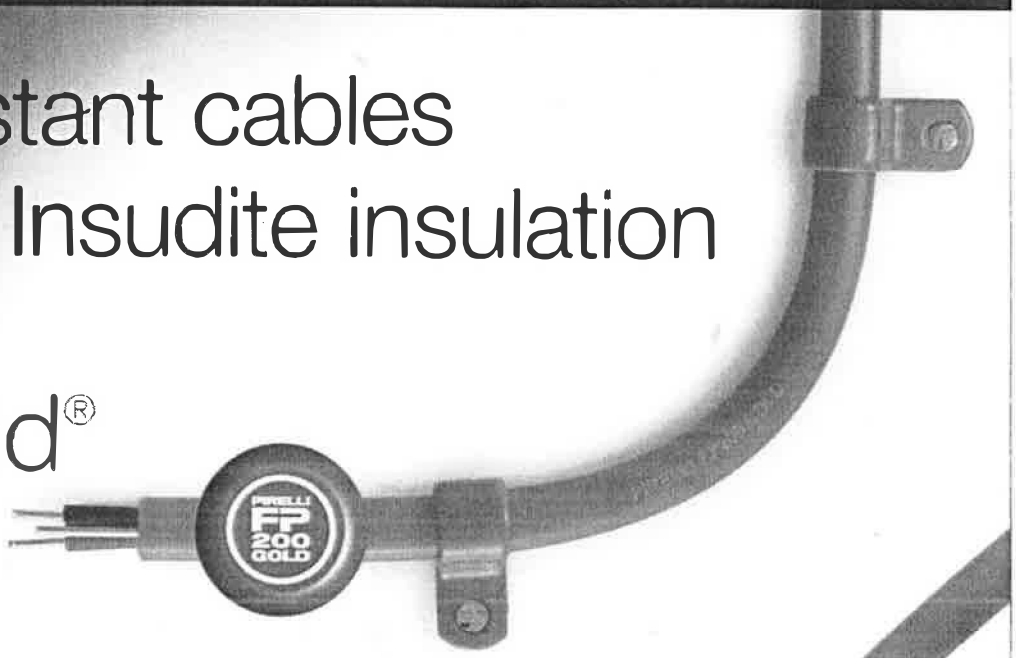

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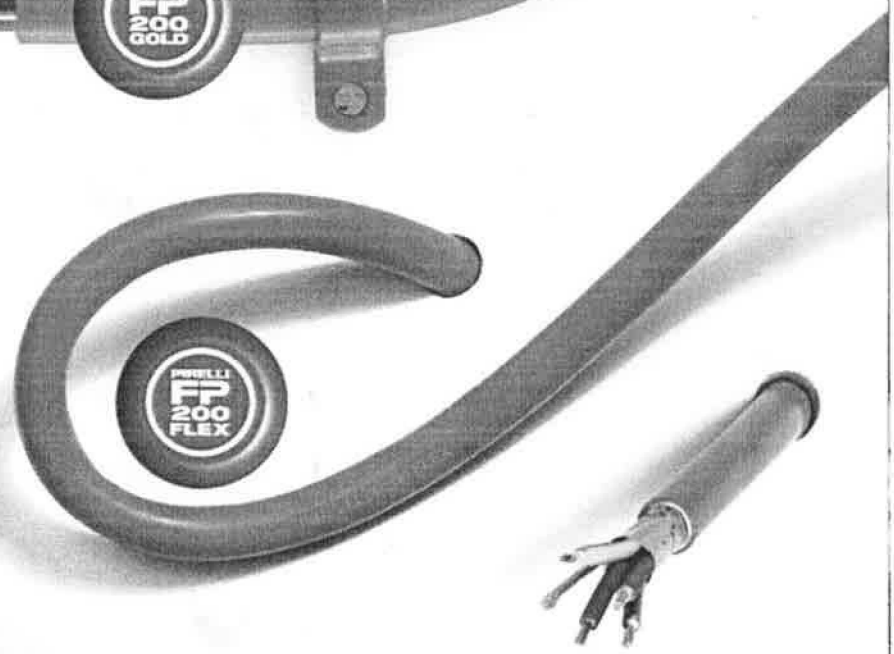

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TABLE 2: CHILLED CEILINGS AND BEAMS – COST COMPARISON

	Fan coil unit	Chilled ceiling with perimeter chilled beam	Passive chilled beam	Active chilled beam
	£/m² (gifa)	£/m² (gifa)	£/m² (gifa)	£/m² (gifa)
Shell and core: all figures in terms of gross internal floor area (gifa)				
Disposal installation – condensate drainage	1.20			
Heat source – gas-fired boilers, gas supply, twin walled stainless steel flues	6.50	6.50	6.50	6.50
LTHW installation				
Pipework distribution in plantrooms and risers, pumps, pressurisation unit, water treatment, insulation	7.00	7.00	7.00	7.00
CHW installation				
Roof mounted, air-cooled packaged chiller plant, pipework distribution in plantrooms and risers, pumps, pressurisation unit, water treatment, insulation	25.00	23.00	23.00	23.00
Air handling plant				
Supply/extract air handling plant, ductwork to plantrooms/risers, insulation	19.00	23.10	23.10	23.10
Electrical installation – allowance for electrical supplies to mechanical plant	3.90	3.90	3.90	3.90
Controls installation				
Head end supervisor, motor control centres, outstations, sensors, controls and all power and controls wiring	13.70	13.90	13.90	13.90
Total shell and core cost	**76.30**	**77.40**	**77.40**	**77.40**
	£/m² (nia)	£/m² (nia)	£/m² (nia)	£/m² (nia)
Category A fit out all figures expressed in terms of net internal area (nia), based on a net:gross efficiency of 75%				
Floor finishes – extra over for:				
350mm raised floor void, including cavity barriers, for displacement ventilation		4.00	4.00	
Seals to form airtight plenum		5.00	5.00	
Forming holes in raised floor tiles and fixing free issue supply air diffusers		0.60	0.60	
Dust sealing to underfloor plenum		1.00	1.00	
Ceiling finishes – extra over for:				
Cost of perforated metal mega panel suspended ceiling suitable for chilled ceiling installation		22.00		
Disposal installation – condensate drainage	5.60			
1) LTHW installation				
LTHW Distribution, pipework, insulation, connections to fan coil units	17.50			
Perimeter heating, pipework, insulation, trench heating installation		26.60	26.60	26.60
2) CHW installation				
Chilled water distribution to office areas at high level, pipework, insulation, connections to chilled elements		32.00	29.00	29.00
Chilled water distribution pipework, insulation, connections to fan coil units	26.50			
Chilled ceiling elements, 70% active tiles, copper elements, flexible connections, shut off couplings.		69.00		
Passive chilled beams, flexible connections, shut off couplings			45.00	
Active chilled beams, flexible connections, shut off couplings				50.00
Ceiling mounted four pipe fan coil units	32.10			
3) Air handling				
Supply and extract ductwork, insulation grilles and diffusers	47.20			
Supply and extract ductwork, insulation, extract grilles				35.00
Extract only ductwork and grilles		27.20	27.20	
Supply only floor grilles		12.50	12.50	
4) BEMS installation				
Sensors, control valves, power, control and network wiring	12.00	15.00	15.00	15.00
Total Category A fit out cost	**140.90**	**214.90**	**165.90**	**155.60**

The following exclusions apply to the costs shown in the table: inflation beyond second quarter 2001; general builders' work; main Contractor's preliminaries, attendances, overheads and profit; professional fees and prescribed fees; contingency and design reserves; tax allowances; vat.

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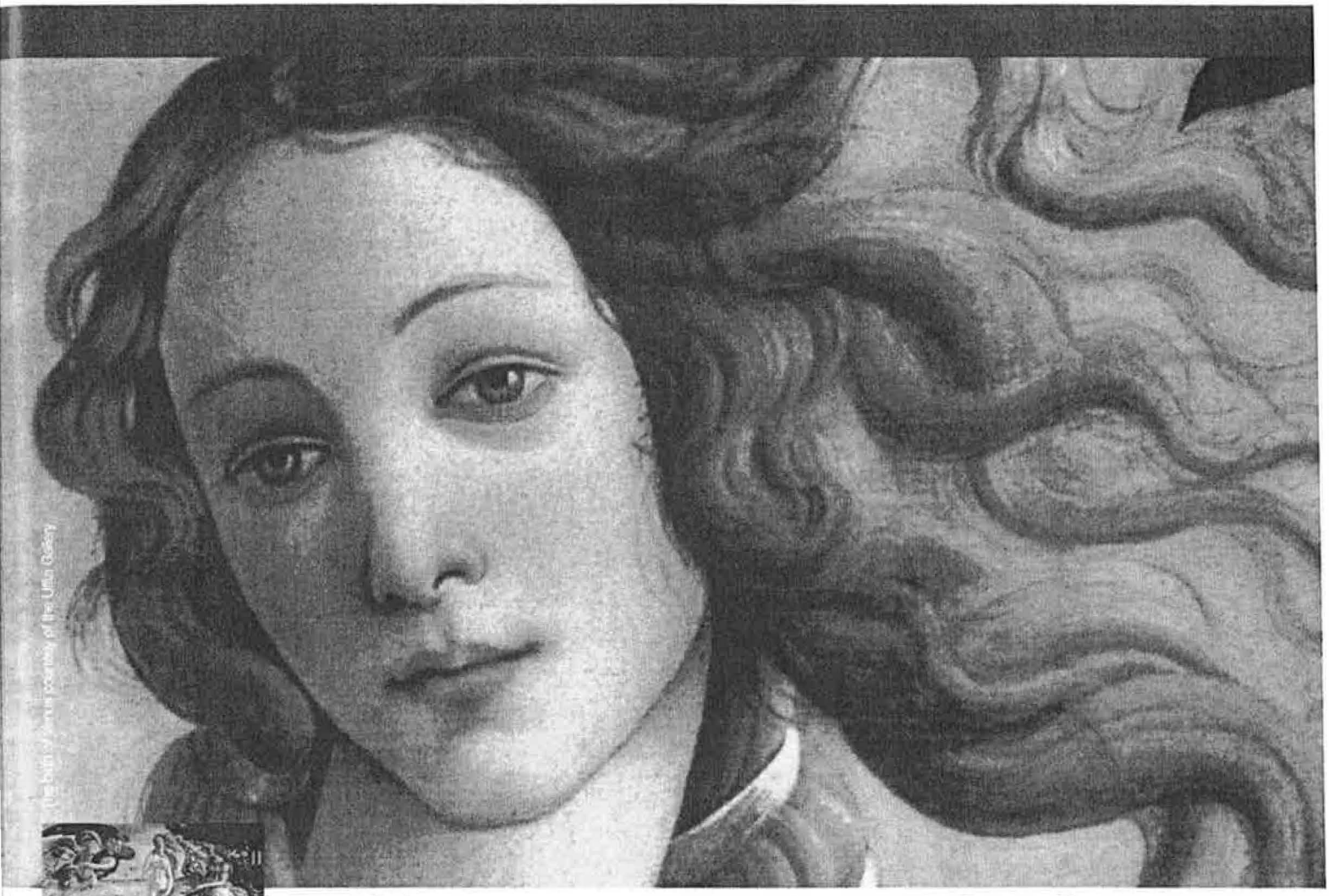

(The birth of Venus courtesy of the Uffizi Gallery)

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