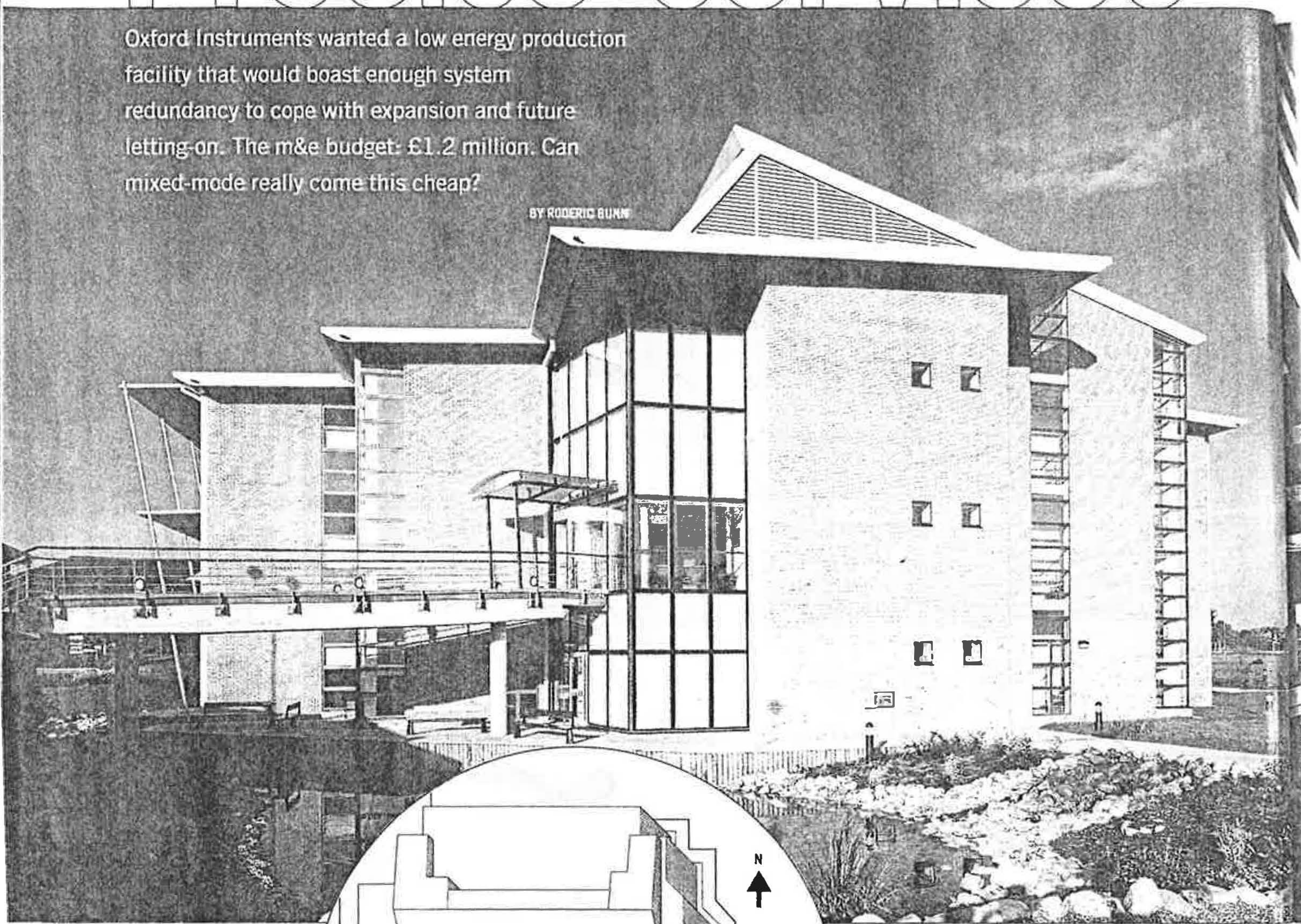
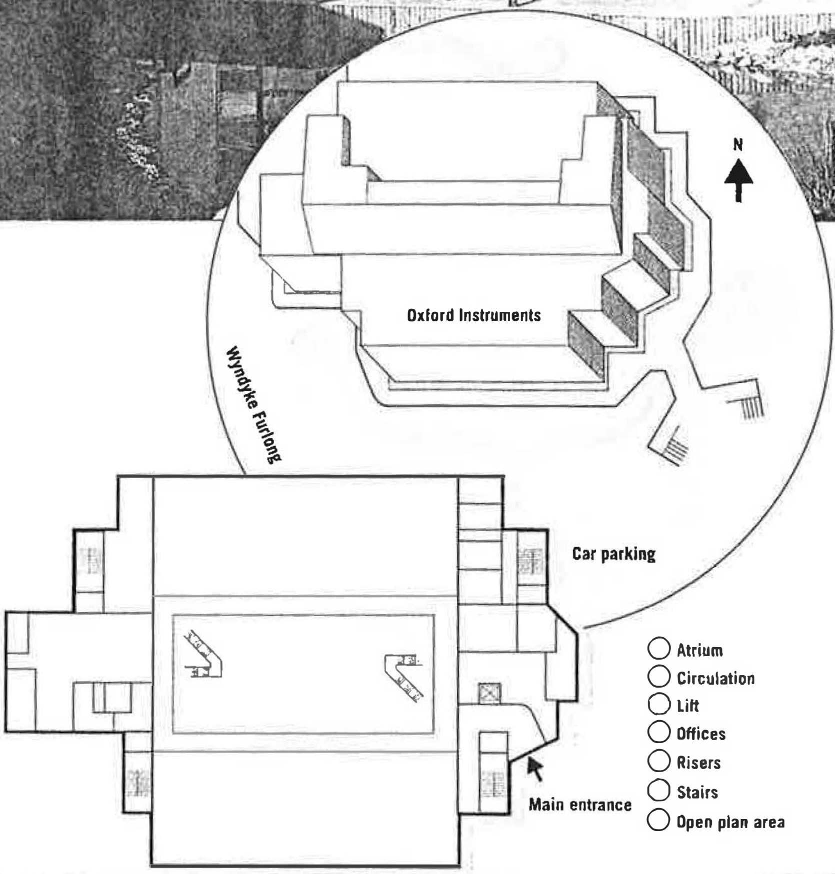
Precise services

Oxford Instruments wanted a low energy production facility that would boast enough system redundancy to cope with expansion and future letting-on. The m&e budget: £1.2 million. Can mixed-mode really come this cheap?

BY RODERIC BUNN

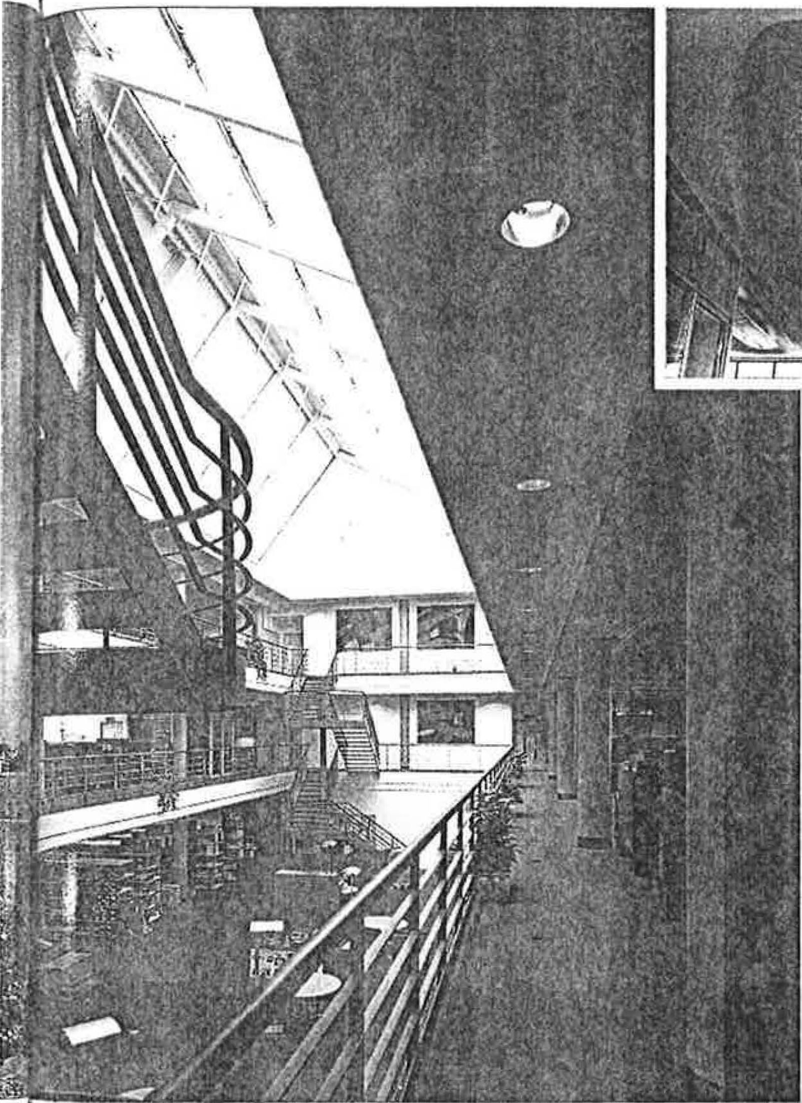


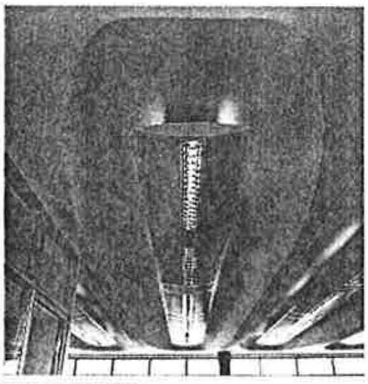


When precision instrument manufacturer Oxford Instruments decided it needed a new headquarters, project consulting engineer Whitby Bird & Partners pointed to the award-winning PowerGen building in Coventry[1] and said: "Why not have something like that?".

The drive for "something like that" didn't just mean shallow-plan floors, mixed-mode ventilation, openable windows and high daylight factors. It extended to PowerGen's bespoke concrete coffer – the tapered, flattened trough that is very much a signature of the PowerGen hq's architect, Rab Bennetts.

Like PowerGen, Oxford Instruments' £5.2 million building has adopted the increasingly fluent vocabulary of mixed-mode engineering. Hence the underfloor mechanical ventilation with heat recovery, stack-assisted natural ventilation via the atrium and openable windows for additional cross-ventilation. A borehole has also been sunk for future use as a passive cooling device.





ABOVE: Detail of the concrete coffered ceiling, virtually identical to the design used at PowerGen's hq in Coventry.

LEFT: The atrium roof is complete with glazed smoke vents. These double up as stack ventilators, helping to ventilate the building during summer.

The construction manager, Barwick, contracted concept architect Michael Waite Associates, project architect Capaerius and consulting engineer Whitby Bird & Partners to devise the low energy design strategy, with (recently-collapsed) Isovel Contracts handling the detailed m&e design and installation. Work started on site in November 1996, with completion in March 1998 and occupation in April this year.

The building is located in Abingdon Business Park, an incongruous setting given that the Park is otherwise peppered with 1980s architectural banality. The light brickwork and bright green external brise soleil of Oxford Instruments certainly marks a cheery departure from the predominately brown-bricked, chocolate-glazed B1 sheds.

Approached from the south, visitors to the 4800 m² building are channelled towards it via a small timber bridge, which leads to a planar glazed reception area at first floor level. The site plan (left) shows how the cores have been pushed out to the east and west ends of the building to allow for maximum open-plan space in the centre. The main occupied space is over three floors, with 15 m-wide bays either side of a fully-glazed, east to west-oriented atrium.

Oxford Instruments makes precision measuring devices for use in industrial analysis, the (light) assembly of which is carried out on the building's ground floor. Sales, administration, accounts and the research and development departments occupy the open-plan space on the first and top floors.

The majority of the cellular accommodation (plus the board room, small laboratory and staff restaurant) is in the cores. Toilet facilities run through these cores on all floors, along with the primary supply and extract ductwork in conventional risers.

Horizontal circulation on all levels is along a nominated corridor around the perimeter of the atrium, which contains vertical circulation via open-tread stairs. Given the natural ventilation strategy, Oxford Instruments has wisely nominated the window perimeter zone as a circulation route, reducing the potential for local ownership of the openable windows and internal blinds which so often leads to occupant conflicts.

Oxford Instruments is not exactly sweating its building. Although around 110 staff work in the Abingdon plant, the average daily occupancy is only about 90 – extremely generous given the building's gross floor area. The hours of occupation are 07.00 h to 18.00 h, with cleaning between 18.00 h to 20.00 h. Most ambient lighting is switched off on timers. Lighting in the cellular offices is controlled on PIR with local override.

Environmental engineering

As is becoming the norm with passive solar architecture, the designer set out to thermally condition the space using the building's fabric. This means good control of solar gain and daylight, high levels of fabric insulation and careful control of thermal properties.

The usual design iterations resulted in 50% glazing for the north and south facades, the latter protected by a fixed brise soleil. Each shade is comprised of fins bolted at approximately 45°. Some of these have a tendency to deflect in high winds, causing something of a maintenance headache.

Fabric insulation is reasonable for a 1998 passive solar building, with U-values of 0·35 for the walls, 0·25 for the roof and 1·90 for the glazing. The latter is comprised of low emissivity glass in double-glazed openable units.

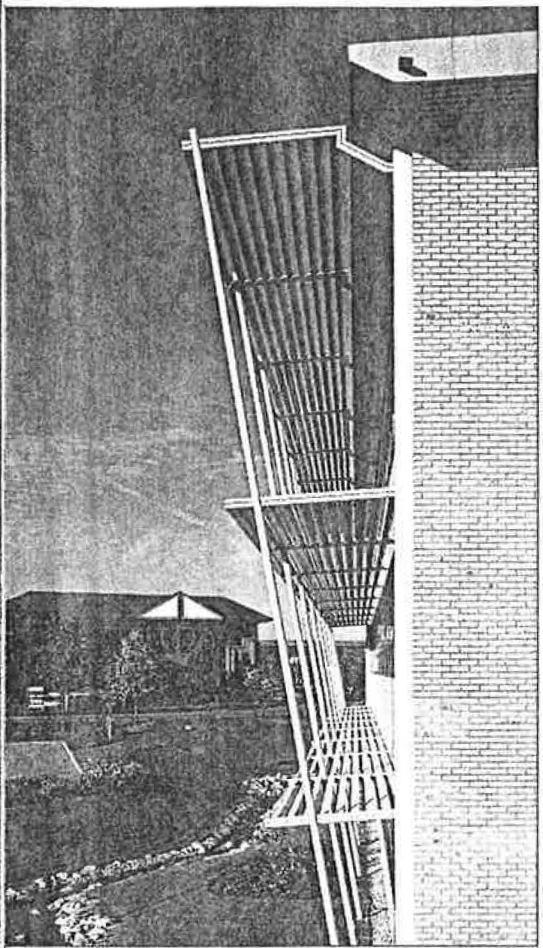
Decked in groups of three, the windows are all openable by hand levers. Even the toplight 2·8 m above the floor has a lever, which rather suggests the glazing units were a block purchase. Occupants tend to open the lower or middle unit when they need additional ventilation, but a hand-winched or motorised toplight would have been far more useful.

Of course, motorised toplights would also have been a practical and low energy way to run night purging, but the client was more worried about security than fan power, so night cooling is carried out using the air handling plant.

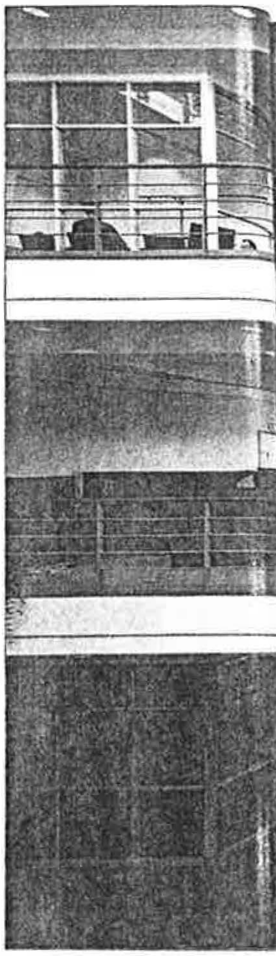
The atrium roof has glazed smoke vents which double as stack ventilators when internal temperatures rise above 21·5°C and external ambient is above 15°C. They will close when wind speed is above 15 m/s, and if the air temperature in the atrium rises to 25°C – although the latter is unlikely as other ventilation mechanisms will cut in first.

Whitby Bird's building physicists modelled the building on the Tas thermal simulation program. This was used to run iterations on various design solutions, particularly the contribution of the building's concrete structure to its internal thermal stability.

Primarily, the engineer wanted to know if comfort conditions for the site could be main-



Simple solar shades comprise fins angled at 45°. Some of the fins tend to deflect in high winds.



RIGHT: Internal detail of the Oxford Instruments hq. An unashamed PowerGen clone, complete with tapered coffers, soffit-washing fluorescents and a series of low emissivity, double-glazed windows.

tained without introducing mechanical cooling. The designer also wanted to limit the need for space heating.

Based on a European weather year, Whitby Bird found that mechanically-assisted natural ventilation with a night cooling strategy would only mean 2% of occupied hours per year above 28°C, and only 5% of occupied hours above 25°C. It is important to note here that the openable windows are not interlocked with the mechanical ventilation, the operation of which is determined by four space temperature sensors located in the middle of each office space.

Cloning PowerGen's curvaceous pre-cast concrete coffers was as much a pragmatic design decision as it was flattering to good architecture. Indeed, the elegant tapered trough has several attributes which make it ideally suited to the context.

Its primary value is in increasing the exposed area of concrete for both convective and radiant heat transfer. Second, the trough optimises daylight penetration, with the tapering a response to the "back hole" effect that can be caused when daylight-linked fluorescent lamps nearest the perimeter and the atrium switch off. Third, the flattened apex ensures that sound does not bounce around the office, but tends to be focused on its origin.

The building's summer and winter operation is managed by a building energy management system (bems), programmed to switch between operating modes based on a cascade of set-points with varying degrees of priority.

In winter, comfort conditions are achieved through preheating the incoming air by indirect gas-fired heaters in the air handling units (ahus), backed up by full recirculation. The electric panel radiators are disabled during this period.

During occupied hours the ahus supply tempered air at 18°C to the floor plenum, modulating recirculation between 20%-100%. A run-around coil operates between supply and exhaust air streams. The electric radiators are activated until a 20°C space temperature set-point has been reached.

Mid-season operation is defined by an algorithm based on external air temperature, the changeover point currently set at a daily average of 14·5°C. Oxford Instruments has programmed an hour warm-up period to raise the building to 18°C, after which internal gains will kick-in to raise space temperature to around 19°C-20°C using the run-around coils and electric panel radiators.

Night cooling during the mid-season closely follows BSRIA technical guidance[2]. Three set-points are measured by the bems: slab surface temperature, peak average zone temperature (above 24°C) or when average day-time temperature in any zone rises above 22°C. A 24-h deadband locked into the bems prevents sequential cooling and preheating.

Early on in the project, Whitby Bird contemplated using Airdeck[3], a Termodeck-type system that relies on steel panels to create air supply pathways over concrete soffits. Although heat transfer rates might be better, the difference in energy consumption between Airdeck and a simple plenum supply was within the range one would normally expect from operating different ventilation regimes.

M&E services

Dalair ahus in the east and west cores supply 100% fresh air to 450 mm-raised floor plenums, with discharge into the space on all floors via ubiquitous swirl diffusers.

There are separate ahus serving the small "wet lab" on the second floor and the toilets on each floor. There is also local extract for the photocopying booths and the adjacent drinks and vending stations, which are also provided on each floor. Hot water is from a smaller calorifier than one would normally expect – this has been achieved by trace heating the distribution pipework which effectively increases the storage capacity.

The main ahus are equipped with Ambi-Rad indirect gas-fired heaters, air filters and a heat exchanger section for the groundwater cooling coils (currently disabled). Return air is recovered from the atrium to be dumped or recirculated as appropriate. In summer, air is exhausted via the atrium smoke vents.

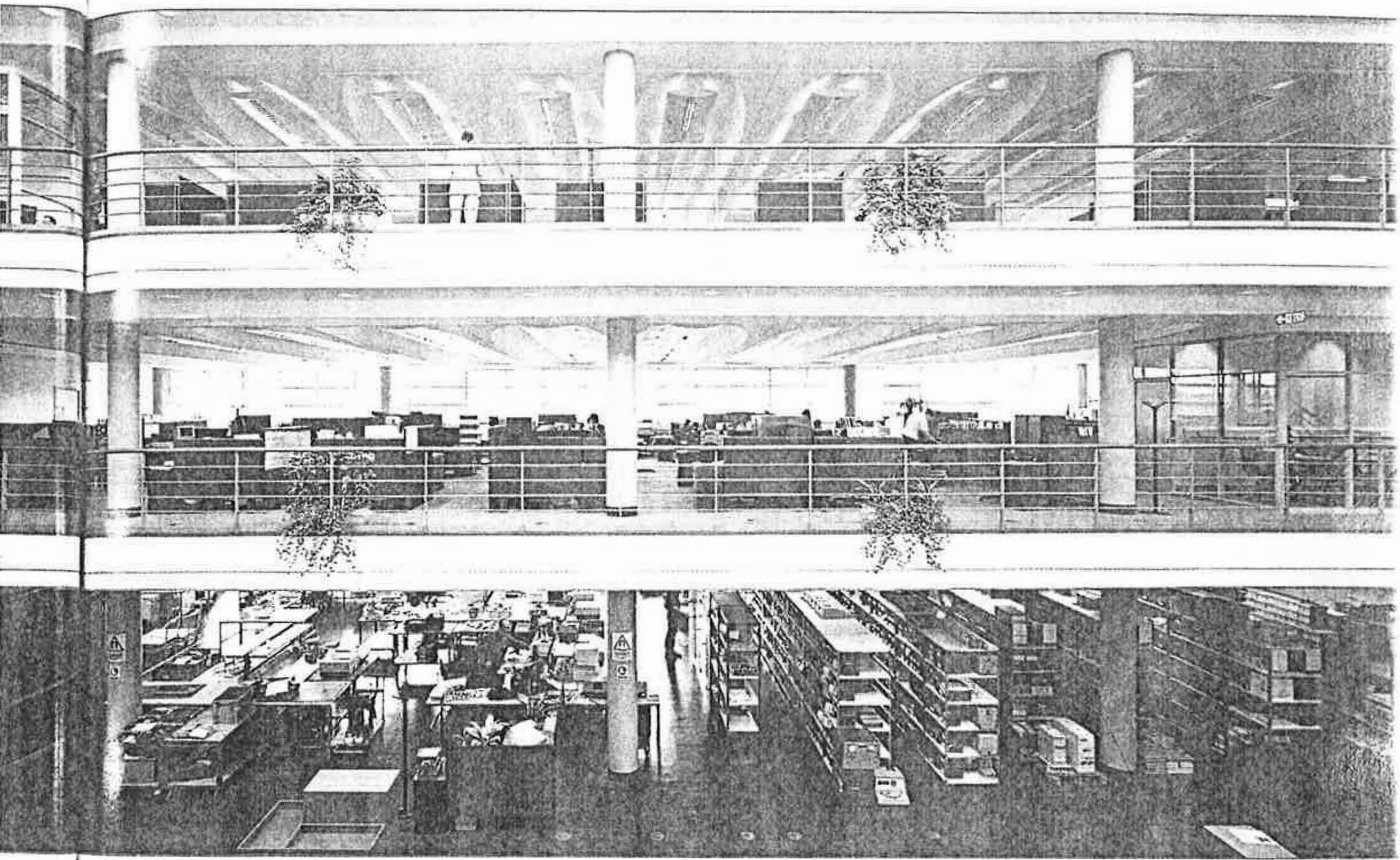
Electrical services rely on a single, conventional 11 kV incoming supply serving Dorman Smith lv switchgear. Power distribution under the raised floor in the open-plan areas is by Barduct power busbars. The structured cabling terminates at three-way blocks on a grid, enabling power, voice and data to be taken to any outlet using a 5 m fly lead.

Dado power and data trunking is used in the cellular offices and meeting rooms, a far more elegant solution than property developers tend to believe.

The lighting installation comprises a range of fluorescent fittings for the open-plan areas, plus compact fluorescent downlights in recessed fittings for the offices and corridors.

Borehole cooling

Whitby Bird wanted to avoid mechanical refrigeration while providing suitable cooling capacity for a future increase in loads. Given the proximity of water-bearing Corrallian lime-



stone, a 15 m-deep borehole was drilled for extracting groundwater, which can then be passed through heat exchangers in the ahus.

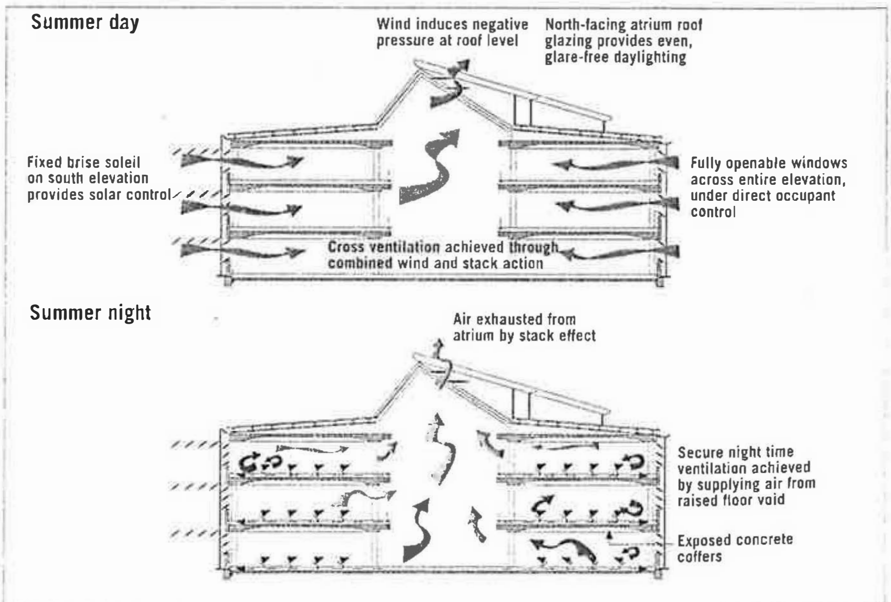
At the time of writing the Environment Agency has not granted Oxford Instruments an extraction licence, even though at current requirements the borehole would only be needed for one or two weeks per year at very modest rates of extraction. A seven-day, full-flow extraction test was carried out last month, measuring the borehole's rate of recovery. The results were said to be "encouraging".

Initial operation

As the Oxford Instruments building has only been occupied since April 1998, the client is still learning how to operate it.

Teething problems include the atrium louvres, the opening and closing of which has proven to be rather unruly. A second rain sensor has been added as the single sensor was unable to pick up angled rainfall.

Roger Collins, facilities manager at Oxford Instruments, pilots the complex bems with relish, keeping close tabs on the various ventilation, heating and night cooling set-points. The bems is, he said, very easy to drive, even



Classic mixed-mode operation. Although the Oxford Instruments hq is primarily mechanically ventilated, the building also has natural ventilation, but with no interlock between the air handling units and the openable windows. Operation of the mechanical ventilation system is determined by four space temperature sensors located in the middle of the office space. The sensors are also used to control the wall-mounted electric heaters.

though Collins regards some of the detailed pre-cooling parameters as being somewhat surplus to requirements.

The other major aid to the smooth running of the building is the extensive energy metering, separate meters being installed on a floor-by-floor basis to clock electricity use for lighting, heating and small power. The latter are not disagregated.

The plantrooms are effectively open plenums, obviating the need for supply intake flanges up against the plantroom louvres. The dry air coolers for the computer room and laboratory are inside the plantroom, close to the ahu intakes. It is probable that the waste heat short-circuits into the ahus, with direct solar gain on the plantroom in summer.

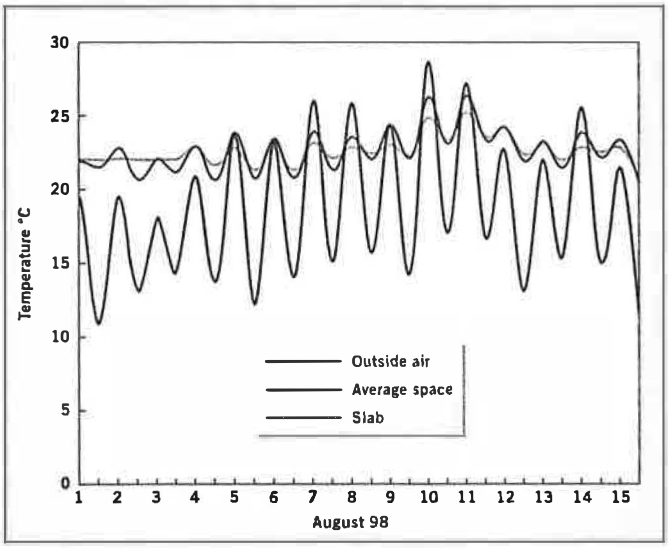
It is testament to the capacity of the building structure that this gain seems to be accommodated with little or no penalty. In fact, in August when external temperature rose to 29°C, space temperature just touched 27°C.

Lighting controls (monitored by the bems) are not problematic. Passive infra-red detectors are used to modulate the fluorescent fittings, a decent deadband and a timed "off" at night contributing to the system's stability.

The facilities manager will be monitoring the building (as will Total Controls and Whitby Bird via a modem connection). It should be possible to index performance against *ECON 19* benchmarks in a year's time.

There is no denying that the building is a mini-clone of PowerGen, both visually and technically. While that is laudable, Oxford Instrument's facility is not as mixed-mode in operation as its more celebrated cousin (although Oxford Instruments has so far escaped installing a chiller). PowerGen's toplights are motorised and under the control of a bems, enabling the mechanical ventilation to be throttled back or switched off when conditions allow.

Recent monitored data showing the production facility's performance during a hot spell.



At Oxford Instruments' hq, the natural default is background mechanical ventilation (at 2 ac/h), with natural ventilation coming from the manually-operated windows. The fans are wound up to 6 ac/h for night cooling and periods of high temperatures.

The building's admirable thermal stability is helped by modest internal gains, although in time Oxford Instruments will probably grow to fill the space available.

The adage: "If you are going to copy, copy from the best" doesn't quite wash in architectural circles. Accusations of plagiarism are levelled rather more readily in that discipline than in the precise world of engineering.

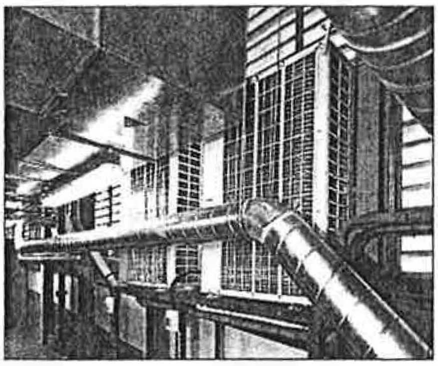
References

[1]Brister A, "The new generation", *Building Services Journal*, 3/95.

[2]Fletcher J and Martin A J, "Night cooling control strategies", Technical Note *TN 5/96*, BSRIA, 1996.

[3]Barnard N, "Choosing the right fabric", *Building Services Journal*, 3/95.

This article is based largely on the performance specification by Whitby Bird & Partners, information provided by Oxford Instruments' facilities manager Roger Collins and input from former Isovel Contracts project leader Andrew Lambert.



The computer room condensers, along with the lightweight construction of the plantroom, theoretically combine to produce heat regains.

The building is liberally endowed with energy meters – crucial for keeping an eye on energy consumption.

Oxford Instruments (Industrial Analysis Group), Wyndyke Furlong, Abingdon Business Park, Oxfordshire

Isovel Contracts, the design and build contractor for the Oxford Instruments hq, went into receivership during the research for this building analysis. It has therefore not been possible to obtain complete information and detailed costs.

Client
Barwick Property Consultants
Project manager and management contractor
Barwick Construction Management
Architect
Michael Waite Associates (concept), Capaerius
M&E consulting engineer, building physicist, structural and civil engineer
Whitby Bird & Partners
Quantity surveyor
Barwick Property Consultants
M&E contractor
Isovel Contracts
Systems integrator
Total Control

Mechanical suppliers
AHUs: Dalair
Booster sets: Hydroset
Ceiling diffusers: GDL
Computer room a/c: Daikin
DX cooling: Daikin, Isovel
Dampers: Actionair
Ducts: Ductwork by Design
Fans: VES Andover
Floor grilles: GDL
Gas-fired heaters: Ambi-Rad
Glazing: Velfac
Louvres: GDL
Panel radiators: Dimplex
Pumps: Grundfos
Pressurisation: Armstrong
Raised floors: PAF
Sound attenuation/masking: Envirosound, CP Sound
Toilet extract: NuAire
Valves: Hattersley
Water heaters: A O Smith

Electrical suppliers
BEMS and controls: Total Controls, Allerton
Communications: Isovel
Dado trunking: Marshall Tufflex
Electrical accessories: MK Electric
Electrical distribution: Merlin Gerin
Fire alarm/detection systems: Isovel
Lift: Stannah
Lighting controls: Total Controls
Louvre and smoke ventilation controls: SE Controls
Luminaires: Luxonic
LV switchgear: Dorman Smith
Power busbar: Barduct
Trace heating: IPS
Computer room ups: Chloride
Water leak detection: Andel

Contract details
Tender date: January 1997
Tender system: Two-stage
Contract period: 9 months

External design conditions
Winter: -4°C/sat
Summer (non a/c): 30°C db
Summer (a/c): 30°C db

Internal design conditions
Winter: 18°C min
Summer (non a/c): 27°C
Summer (a/c): 22°C
Circulation/toilets: 19°C
Exceedance levels
>28°C for 2% of occupied hours, >25°C for 5% of occupied hours

U-values (W/m²K)
Walls: 0·35
Roof: 0·25
Glazing: 1·90

Structural details
Floor-to-ceiling: 2·6 m

Occupancy
Offices: 1 person/10 m²

Engineering data
Gross floor area: 5000 m²

Loads
Floor average: 35 W/m²
Equipment: 15 W/m²
Lighting: 15 W/m²
Occupancy: 5 W/m²

Ventilation
Supply air temp: 18°C
Air change rates
Normal: 2 ac/h, daytime summer boost: 6 ac/h
Filtration EU category: 5

Lighting
Lux levels
Offices: 500
Daylight factor: 6% (ave)

Costs
Total cost (including land): £6.4 million
M&E, fire, security and data systems: £1.2 million