Downtown uproar

When your skyscraper starts screeching, who you gonna call? **Mick Hamer** investigates

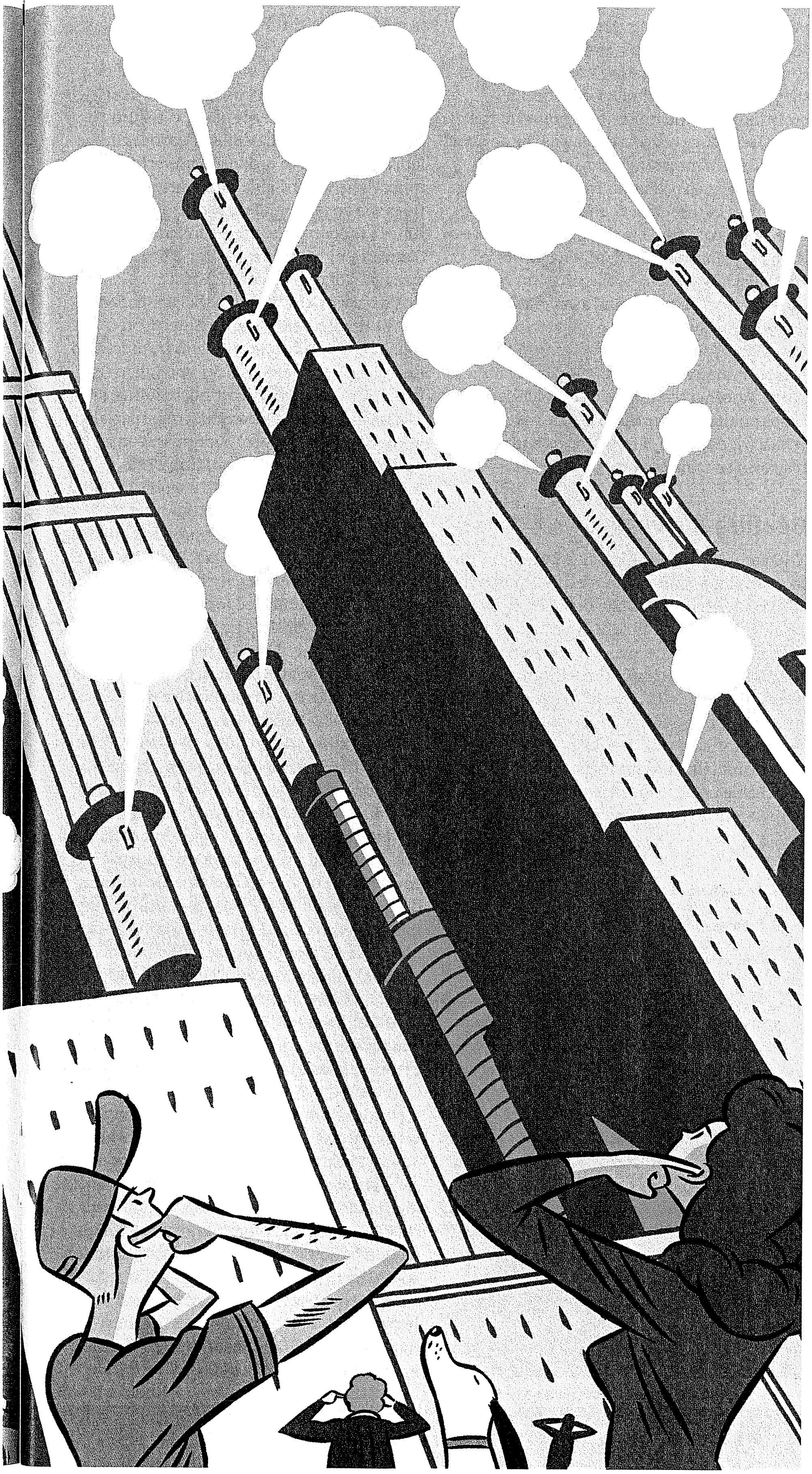
JASON FORD

IT IS Queen Elizabeth II's favourite soap opera, so someone had better sort this out. Whenever outdoor shots in the world-famous TV show *Coronation Street* are filmed on a blustery day, its sound engineers have to inject extra background noise into each scene. Why? Because half a mile away, a building is whistling in the wind.

Beetham Tower, the 171-metre centrepiece of Manchester's new city centre, is not due to open until October, but local residents have been complaining about the noise pollution since April, when the distinctive 14-metre-high glass and steel "blade" on the tower's roof was completed. On windy days, the air around the blade vibrates at a frequency of 250 to 260 hertz – close to middle C on a piano. People have variously described the sound as being like a flute or a UFO landing. "In 20 years of investigating complaints about noise, I have never come across anything like it," says Rachel Christie, head of the local council's environmental health department.

The Beetham Tower is not the first building to make a disquieting noise, however, and nor will it be the last. Normally building noise is trivial and drowned out by the hustle and bustle of a busy city, but each year around the world one or two new buildings make loud and irritating noises. The problem is only likely to get worse, too. Not only are buildings rising higher – and so becoming exposed to constant strong winds – many are also sprouting eco-friendly features such as sun-shade louvres designed to reduce the need for air conditioning. These are perfect for generating wind whistle. So can we do anything to keep the cities free from screeching spires?

One of the basic mechanisms behind building noise is the same one that generates a tone as you blow across the top of an empty beer bottle. The rim of the bottle disturbs the airflow and produces a small eddy, or vortex,



in the neck of the bottle. The oscillation frequency of this vortex is inversely related to the size of the bottle neck and directly proportional to the wind velocity.

As you blow harder across the neck, the oscillation frequency of the vortex increases, until eventually it matches the natural resonant frequency of the beer bottle's cavity. The bottle-top eddy acts as a piston on the air in the bottle (see Diagram, page 36), and your bottle produces a satisfyingly audible sound.

The architectural equivalent of bottle necks are louvres, gratings, railings and other facade features with regular spacings. Eddies generated by grating lattices are particularly potent sources of whistles – even without a resonating cavity. "You get lattices at certain angles, and it sounds like the wind going over fifty beer bottles," says Brian Howe of Canadian firm HGC Engineering, based in Mississauga, Ontario.

Angle of attack

Researchers in Vienna, Austria, stumbled across the phenomenon 23 years ago while testing a new design for the Vienna General Hospital for structural stability in high winds. The design featured two 13-storey towers whose facades included metal grating walkways for maintenance workers. Wind tunnel tests by researchers at Vienna-based Arsenal Research and the Vienna University of Technology turned up no structural problems, but the team did uncover an "unexpected and unpleasant result" (*Journal of Wind Engineering and Industrial Aerodynamics*, vol 11, p 133). When the speed of the wind in the tunnel reached 55 kilometres an hour there was a very loud sound at 2000 to 2500 Hz.

Intrigued by this phenomenon they carried out further tests and found that the wind speed and direction was critical. The angle of attack had to be between 0 and 15 degrees to the plane of the mesh to make the noise – pretty much exactly the angle needed to make a sound on a flute. And just as flautists can produce higher notes by blowing harder than normal – it is called overblowing – the researchers found that doubling the wind speed to 110 km/h more than doubled the frequency of the sound.

The researchers quickly deduced the source of the noise from the fact that it disappeared when they removed the walkway grating from the wind tunnel. So the solution was simply to reduce the size of the mesh holes from 40 to 31 millimetres, and increase the gauge of metal in the mesh from 1.5 mm to 1.8 mm. The result was that it would take a wind speed of 130 km/h to create a noise, something that would only be expected to occur once in 50 years.

Identifying acoustic problems before ▶

construction begins is great, but it doesn't always happen that way. One of the most notorious whistling buildings was New York's 248-metre Cityspire tower between 6th and 7th Avenues in midtown Manhattan. In 1991 the building's managing agents were fined for the noise generated by louvres around the dome at the building's summit.

According to a musician interviewed by *The New York Times* at the time, the louvres produced a tone about an octave above middle C – around 523 Hz. The din, like a second-world-war air raid siren, could be heard all the way from 3rd Avenue to 9th Avenue. Not surprisingly it produced a flood of complaints. The building's managers eventually took out half the louvres, lowering the resonant frequency and increasing the wind speed needed to initiate whistling. It was enough to stop the noise.

One of the few whistling buildings ever to have been studied comprehensively is the Expo Pavilion in Hook of Holland. It was the subject of a paper presented by Werner Hoffmans of TNO, the Dutch national research organisation in Delft, to a meeting of the Acoustical Society of the Netherlands in 1999. The Expo Pavilion's distinctive design includes a long, angled rear wall roughly aligned with the direction of the prevailing wind and made of a grating with 9 centimetre by 4 centimetre cells.

When the wind speed reached 72 km/h the grating produced an ear-splitting 100-decibel howl at 2500 Hz – a bit like someone blowing a penny whistle loudly in your ear. By testing a section in a wind tunnel, Hoffmans's team confirmed that the grating was the culprit: as they increased the wind speed it began emitting the same intensity of sound at the same frequency of 2500 Hz. It was the acoustic equivalent of matching a fingerprint.

Solving such problems means identifying the source of the vortices and position of the resonant cavity, and breaking the link between them, says Joachim Golliard, a wind-noise specialist at TNO. One of the simplest ways to do that is to divert the wind away from grids or lattices to avoid creating the vortices in the first place. You can also fill in some of the holes, or remove the resonating cavity if there is one. Another technique is to create serrated edges on the structure to produce vortices with a wide spread of frequencies and so avoid triggering any resonance.

Beating the vortex

TNO came up with an elegant solution for the Expo Pavilion. The team added a second grid of light chicken wire to the first grid. It made an almost imperceptible difference to the look of the building, but a massive difference to the sound. "When you apply the wire grid you destroy the nice structure of the vortices, preventing them from triggering the acoustic resonance," says Golliard.

Fortunately most gratings don't make any noticeable noise. "Not all geometries likely to whistle will do so, as it depends on other factors, such as the direction of the wind and the surface finish of the metal," Golliard says. However, gratings are not the only problem, as the Beetham Tower has shown. Even a single projection, a chimney or blade, can hum. At the right wind speed eddies or vortices in the lee can combine to produce a powerful pure tone. These identifiable frequencies stand out from the general hubbub because our brains tune in to them. "People are much more disturbed by a single tone than a broad spectrum of noise," says Howe.

That's why any problem that arises can't just be ignored. However, architects pretty much have to solve the problem from scratch each time if they are unlucky enough to find they have designed a whistling building, says Andrew Allsop, a wind engineering specialist with consultants Arup. "There aren't any perfectly good rules for avoiding wind-induced noise," he says. "What works in one building may be a problem in another."

As if that didn't make suppressing building noise difficult enough, researchers also have very little published research to draw on. Most of the experts contacted for this article didn't know of any published papers, and *New Scientist* has traced just two conference papers and one journal article from the past 25 years. "I have been in discussions with a number of architects who have concerns about wind-induced noise, and I am dismayed that there is a dearth of knowledge about this subject," says Gordon Breeze of the Building Research Establishment at Garston in Hertfordshire, UK. Howe thinks the lack of papers about building noise is a construction industry cover-up. Most one-off problems in building design generate research papers trumpeting innovative solutions, but acoustic problems are – literally and metaphorically – hushed up. Howe's firm specialises in troubleshooting noisy buildings, but he certainly can't talk specifics, he says. "I can't mention any clients," he warns. "And most stories in the press are inaccurate because no one will talk to you about it."

It sounds like a conspiracy theory, but it certainly rings true in the case of the Beetham Tower. The developer, Carillion Building, has called in acoustic experts to stifle the whistle, but has declined to let those experts answer *New Scientist*'s questions. "We think it's early days to be going into the detail," says Carillion spokeswoman Paula Manning. "We are carrying out tests in the laboratory and looking for a workable solution." Here's hoping the culture of silence spreads to the buildings themselves. ●

HOW TO STOP A BUILDING WHISTLING

Sometimes architects can inadvertently design buildings that will resonate like empty beer bottles

● Blow across the top of a bottle and an oscillating vortex forms in the neck, pushing on the air in the bottle cavity. Blow at the right speed and the oscillation frequency will match the resonant frequency of the cavity, producing a low whistle

● In the original design for the Vienna General Hospital, a wind of 55km/h created vortices within the mesh of maintenance walkways on the facades. To prevent these vortices from producing a loud noise – like an array of whistling beer bottles – the building's designers had to increase the gauge of the metal in the walkway and reduce the size of the mesh holes