Proceedings of The Institute of Acoustics

GAS TURBINE NOISE CONTROL

ALAN T FRY

SOUND ATTENUATORS LIMITED

As will be realised over the last decade or more the compact energy density of the jet engine has been incorporated into a gas turbine package making this power available from a shaft. The basic principle, but not wishing to overstate the simplicity, is that the jet engine exhausts directly into a power turbine from which the shaft power becomes available.

Every day familiarity with jet aircraft will signal that a major noise problem is potentially inherent in this solution, and that this noise problem is associated with hot gas exhaust. The high temperature and large volume flow rate of the exhaust leads to unique acoustic and mechanical problems. The compactness has been utilised in both mobile and ground based applications, but the emphasis here will be on the ground base use. The principle ground base uses are for the generation of standby electric power taking the form of "peak lopping" when applied to the National Grid and to the pumping of high pressure natural gas through the corresponding national gas Grid pipeline systems. The power range involved stretches from quite modest sized 50kW units to rather mammoth single frame 100mW power units. Two familiar U.K. jet engines employed for this purpose are special versions of the popular airborne Rolls Royce Avon and Rolls Royce RB211.

The main acoustic problems break themselves down quite simply into:

Intake noise
Casing radiation
Exhaust outlet noise

and Fig. 1 illustrates a typical sound power spectrum for these three separated noise sources.

As can be seen from the graph, theintake noise is exceedingly strong in high frequency contributions, which makes directivity and the use of lined bends a most important feature of inlet noise control. Often complex and thorough inlet dust filtering systems are incorporated which assist this high frequency attenuation. However, large quantities of low frequency attenuation are also required, and to meet this dual demand more ideally the inlet attenuator contains thin high frequency splitters down part of the main low frequency attenuator's airway.

GAS TURBINE NOISE CONTROL

The casing radiation is reduced by two prime techniques:-

a) Traditional brick and concrete power station constructions
b) Specially contrived metal acoustic enclosures

The traditional masonry technique raises no unfamiliar acoustic problems, but the development of the metal acoustic enclosure, with its inherent internal acoustic absorption, has been a notable development from the acoustic engineering and economic point of view. Sometimes it is necessary to employ a double enclosure arrangement where the inner enclosure is comparatively close fitting around the main carcass of the gas turbine assembly. It is quite usual to ensure that the sound pressure levels 100m away from the enclosed units are below 35dBA, and in the immediate vicinity outside the enclosure sound pressure levels around 50dBA are achieved. The exact achievement, more especially on the dBA scale, depends on the detailed spectrum and, of course, the inlet and exhaust attenuation.

Table 1 indicates some field achievements for a good range of gas turbines, rated in traditional units, together with a diesel generator combination.

TABLE 1

Equipment	Typical Sound Levels at 1 metre	Typical Sound Levels o/side Enclosure at 1 metre	Typical Sound Levels o/side Enclosure at 100 metres
Industrial Gas Turbine up to 20 000Bhp	132dBA	74dBA	51dBA
Industrial Gas Turbine up to 38 000Bhp	124dBA	63dBA	40dBA
Industrial Gas Turbine up to 30 000Bhp	123dBA	56dBA	32dBA
Industrial 3 Megawatt Gas Turbine	105dBA	50dBA	26dBA
Twin 1 Megawatt Gas Turbine	114dBA	47dBA	25dBA
Twin 0.5 Megawatt Gas Turbine	109dBA	52dBA	31dBA
Three 325kVA Diesel Generators	116dBA	61dBA	38dBA

More recently the modular concrete cab construction has been employed which, whilst tending towards the technology of the traditional masonry construction, does raise special acoustic problems of its own, more especially with respect to inter-panel sealing. Acoustic absorption is also incorporated in these modular concrete units.

To contrast the effectiveness of various enclosure combinations, Table 2 has been compiled based on a Rolls Royce RB211 noise source.

TABLE 2

Enclosure	SPL at 1 metre	SPL at 100 metres
Single Steel Cab	66dBA	42dBA
Double Steel Cab	59dBA	35dBA
Concrete Cab	56dBA	32dBA
Concrete Cab + Steel Inner Enclosure	45dBA	19dBA

By far and away the most demanding new technology surrounds the hot gas attenuator. The spectrum of Fig. 1 clearly indicates the extremely large content of low frequency noise energy and you will note that the spectrum is continued and specified down to 32Hz. This is quite usual and to some extent essential for gas turbine specifications. Those of you familiar with traditional noise control and architectural acoustics will be aware that reliable information down to 63Hz is often not easily available. Hence, extensions down to 32Hz become very much a speciality of the commerce and information tends to remain guarded. The low frequency problem does not really stop at 32Hz, as the elevated temperature and corresponding increase in the speed of sound leads to increased wavelength for a given frequency. As the low frequency performance of an attenuator is largely governed by geometric scaling, this increased wavelength is equivalent to an even lower equivalent frequency at room temperature - for instance, for a typical hot gas temperature of $500^{o}C$. the wavelength for 32Hz is the same as for 20Hz at room temperature. Hence, the traditional "cold gas" information is required down to 20Hz.

Other problems surrounding the exhaust gas attenuator are:-

- High frequency content
- Thermal construction - expansion, contraction
- Infill type - melting
- Infill retention - high flow rates
- Inlet conditions - turbine volute

These points will be illustrated and discussed in the lecture, together with the basic choice of shape between rectangular, circular and obloid.

Obviously, the hot gas with its associated lower density calls for corresponding revisions in the pressure loss, flow generated noise and directivity index.

Some power turbine sets do give vibration problems and the precision alignment requirements of these machines do not usually allow the application of resilient mounting, except, perhaps, on substantial inertia blocks. Hence, some installations have required that the enclosure system be itself resiliently mounted to minimise the re-radiation of flanked low frequency (100-200Hz) noise.

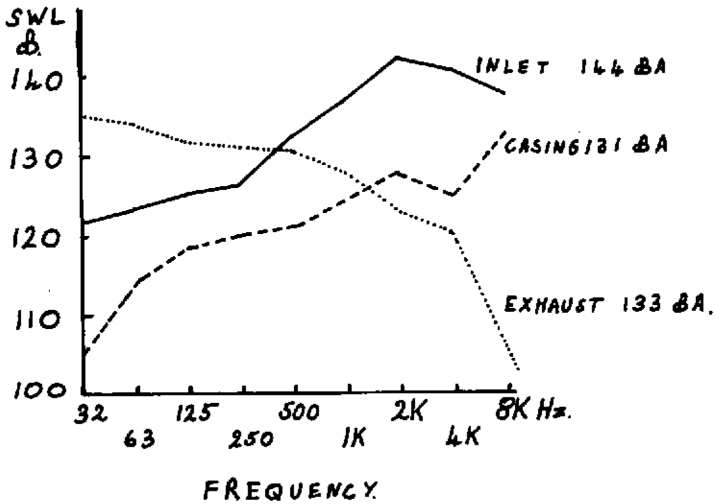
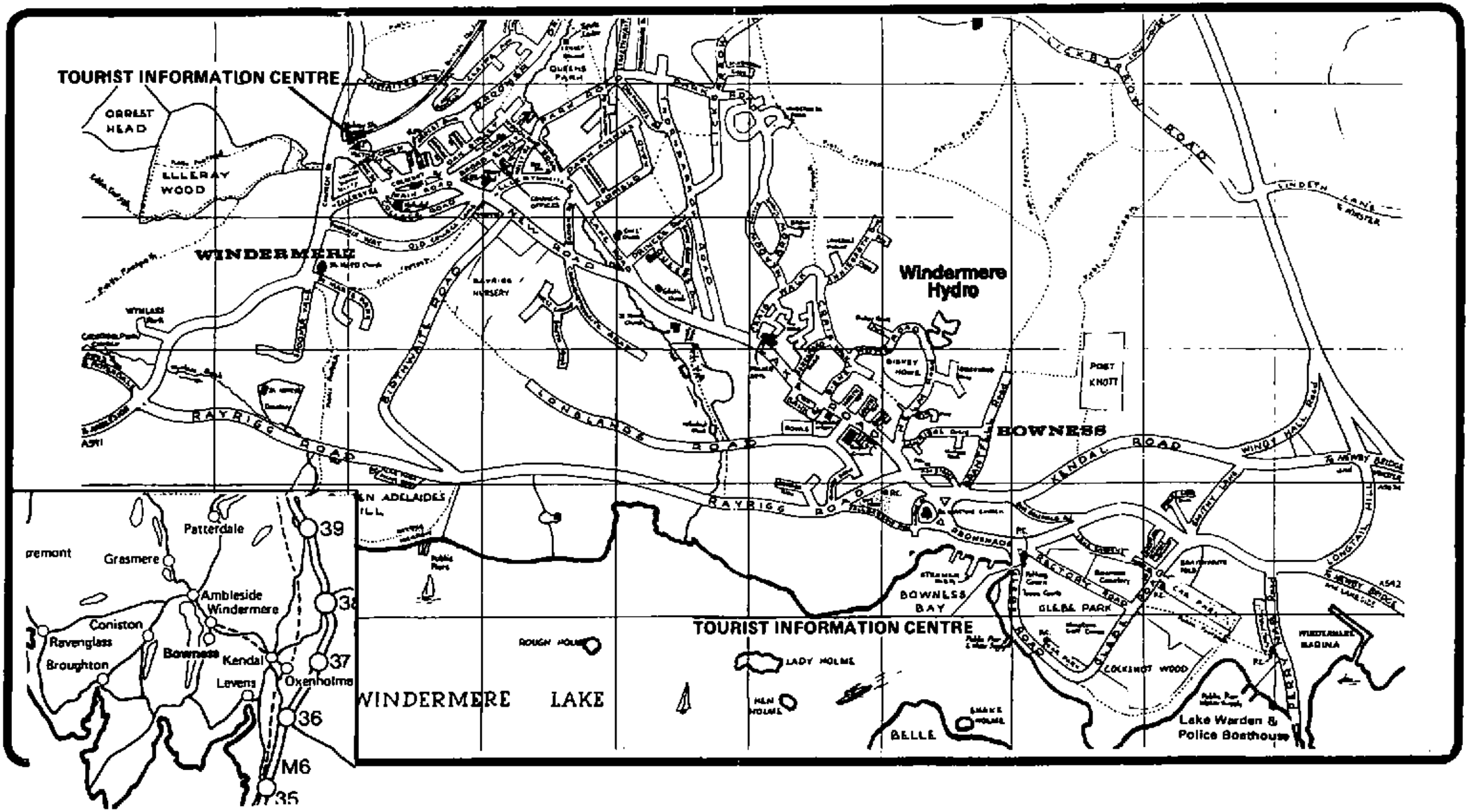


FIG. 1 SOUND POWER LEVELS.

LIST OF CONTRIBUTORS


TOURIST INFORMATION CENTRE
ORREST HEAD
ELLERAY WOOD
WINDERMERE
QUEENS PARK
NEW ROAD
LONGLANDS ROAD
RAYRIGG ROAD
RAYRIGG NURSERY
Windermere Hydro
POST KNOTT
BIESKY HOWE
BOWNESS
KENDAL ROAD
WINDY HALL Road
LONGTAIL HILL
LINDETH LANE
BOWNESS BAY
GLEBE PARK
RECTORY ROAD
TOURIST INFORMATION CENTRE
ROUGH HOLME
LADY HOLME
HEN HOLME
WINDERMERE LAKE
BELLE
COCKSHOT WOOD
WINDERMERE MARINA
FERRY
Lake Warden &
Police Boathouse
A591
A592
Patterdale
Grasmere
Ambleside
Windermere
Coniston
Ravenglass
Broughton
Bowness
Kendal
Levens
Oxenholme
39
38
37
36
35
M6