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A PUBLIC ANNOUNCEMENT SYSTEM FOR GLASGOW CENTRAL STATION

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INTRODUCTION

The problems of design of public announcement facilities in large reverberant spaces are no better illustrated than in Railway Stations. A normal approach to the design will often not be sufficient, because the situation in the space is so marginal that every decibel of direct sound gained is important. Railway stations also have an additional problem of high noise levels created not only by trains but by mail wagons and other vehicles on the platforms.

THE SOLUTION OF THE ACOUSTIC PROBLEM

Glasgow Central Station is a terminal station with 13 platforms, and a fairly large concourse area. The total covered area is about 28,000 m^2 and its volume about 400,000 m^3.

It is not necessary to describe in any detail the acoustic problems which confront the design of an announcement system in this sort of environment. High reverberation time and high and variable background noise are of course the main difficulties.

The design approach started at the distribution end of the speech system. The first calculations showed that, even with directional loudspeakers and careful planning the reverberant sound level could be as much as 5dB above the direct sound that was likely to be achieved at head height. Under these conditions one might typically expect that less than 50% of known sentences would be correctly understood. Equally important is the fact that under these conditions the intelligibility is extremely sensitive to changes in the direct to reverberant difference. An improvement of 1dB can improve the number of sentences understood by more than 10%. Improving the difference by 3dB could increase the number understood from 50% to 90% - clearly the difference bwetween a success and a failure.

The selection and positioning of loudspeakers had therefore to be planned with far more precision than normal and the sound must be directed where it is needed and, as far as possible, nowhere else. To avoid putting any more sound energy than necessary into the space, the variation in direct sound level at head level must be as small as possible.

The first question to be answered was what kind of loudspeakers would give the best solution to our distribution principles. In order to study the best type, the characteristics of a number of loudspeakers were converted to sound pressure isobar diagrams.

Figure 1 shows the vertical plane isobar for a 1200mm column loudspeaker. The outer curve is +2dB relative to the required sound pressure level at the ear. The inner curve shows the -2dB line. These lines are shown because it had been

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decided to try to aim at a variation at ear level of 2dB either side of the mean.

Figure 2 shows the same diagram for a 20° horn loudspeaker. It can be seen that the column speaker has a tighter beam than that of the horn - even though the horn is a narrow one.

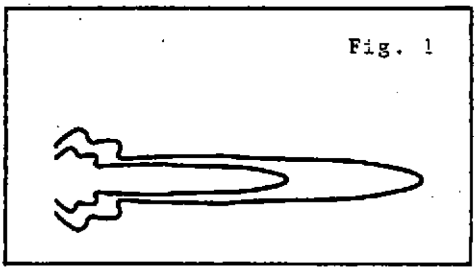

Fig. 1

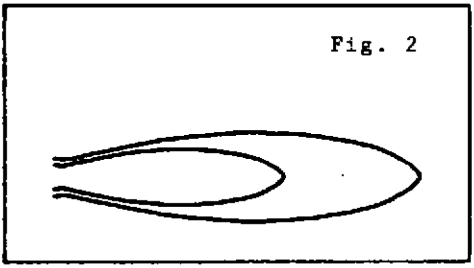

Fig. 2

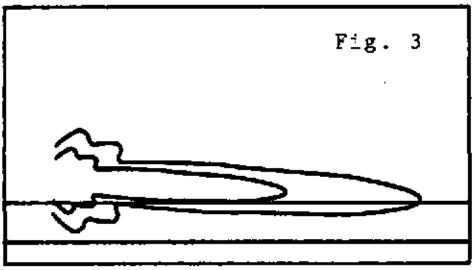

Fig. 3

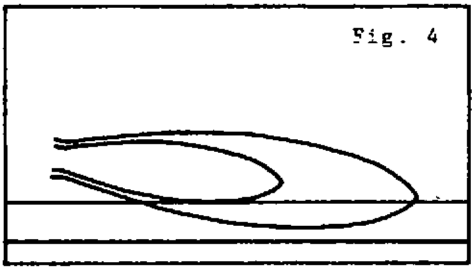

Fig. 4

Figures 3 and 4 show the result of fitting listening height to the isobars. The lower and upper horizontal lines show the ground level and ear height respectively. It can be seen that by tipping the column loudspeaker by a carefully measured angle the aim of trying to achieve the maximum range of ± 2dB could be almost completely achieved except for some slight excess near the loudspeaker. In the case of the horn, less of the distance can be contained within the 4dB range.

When the horizontal plane of each loudspeaker is examined together with the vertical one, a foot print can be established showing the area covered within the 4dB range. The horn has a lower power output for the same "throw" because its horizontal angle is narrower, but set against this was the fact that the column covered more than twice the area of the horn. It was found that the horn would feed about 1.5dB more into the reverberant field for the same direct sound. Furthermore, the horn footprint is roughly elliptical while the column is much more rectangular and the column footprints could be more efficiently fitted together so that in all the column would feed about 3dB less sound into the reverberant field for the same coverage.

As to the placing of loudspeakers, figure 5 shows the arrangement which was used in the final scheme with column speakers facing eachother.

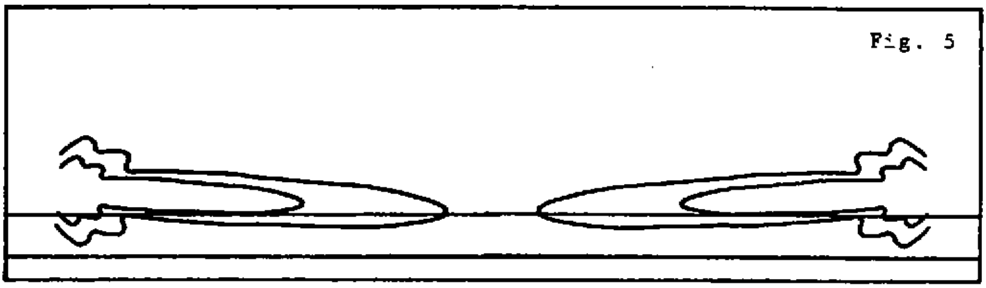
Fig. 5

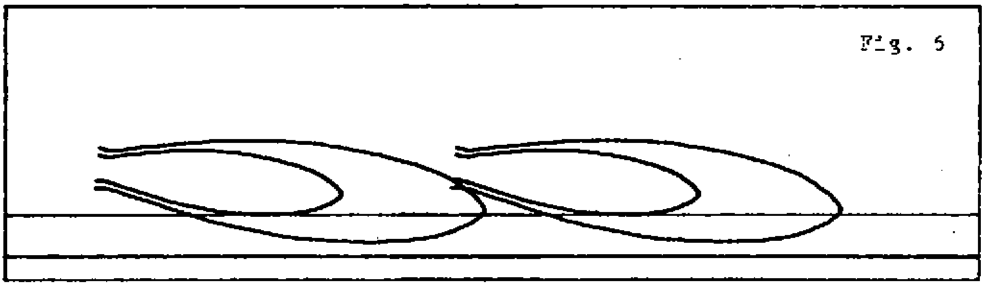
Fig. 6

The best arrangement which we considered for the horns was that shown in figure 6, so that each horn filled the gap in the one in front. This would clearly require the use of delays, and this would be restricting in the concourse areas though it might produce a good solution on the platforms.

The final decision on the loudspeaker selection was made after studying the loudspeaker positions. Either type of loudspeaker needs to be as low as reasonably possible with a minimum at about 2.5m. Rising to a height giving a downward angle of 20° will halve the coverage and so 3dB more sound power would have to be fed into the reverberant field to recover the same direct sound. Raising the physical level higher still will clearly make the situation even worse. If we had to keep the speakers low then for visual reasons columns were preferable.

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THE SOLUTION OF THE ELECTRICAL PROBLEM

It was clearly necessary to be able to vary the sound pressure level of the speech output according to the background noise in the station. Our noise survey showed that in spite of the reverberant space, noise levels varied considerably from place to place. Relating output to background noise had to be done in a quite localised way. The obvious solution was to sense the background noise and adjust the level at each loudspeaker position.

The philosophy of the installation began to emerge. In order to sense and adjust the level locally, power amplification had to be local to each loudspeaker so that not only the signal, but a power supply was necessary at each loudspeaker point. For sensing, it was decided to use the loudspeakers rather than a separate microphone. The sensing takes place after the music fade and just before the announcement is made.

Because of the variation of background noise with time, the range of possible level adjustment was decided at 10dB. A greater range would have been preferable from the point of view of intelligibility, but the reason for stopping at 10dB was to avoid a relatively very loud output occurring when the background noise level dropped after the sensing period. As there is considerable variation in noise level with time - when trains arrive or leave and platform vehicles pass by, it would be preferable to have continuous sensing. The possibility of sensing in the gaps between words was considered but this would have required considerable further research and experimentation and time was not available to do this.

In view of the special requirements of the system it had to be custom designed and the main parts are non-standard. The circuit design resulted in a number of PCBs each performing a specific function which can be easily replaced, should a fault occur.

The Announcer Unit is housed in the Signal Box 1000 yards from the station and is the main operational control in the system. From here, the Announcer is able to pre-select any or all of the zones. Depressing the master switch causes a pulse to be sent to the Central Equipment Rack starting the initialisation sequence.

(1) Fading the music
(2) Sampling the background noise at each loudspeaker
(3) Adjusting the reproduction level at each loudspeaker
(4) Sounding the gong

A boom microphone reduces extraneous sounds from the Signal Box and ensures that the level of speech is reasonably constant. Headphones enable the announcer to gauge the level of speech and provide a degree of control to the speed of speech by adding delayed side-tone to the headphones. There is also a two colour LED to indicate the correct range of voice level.

The Central Equipment Rack is housed in the station and contains the main timing and control circuits and the signal distribution to the loudspeaker

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zones. The signals associated with the system, - music, speech, DC control, logic control and DC supply are isolated by transformers or opto-couplers to eliminate the risk of earth loops. Audio signals are at nominal line level to minimise the likelihood of interference being induced on the audio circuits.

The Timer/Buffer Card provides clock and timing for whole system and controls the timing of the Initialisation sequence. This PCB also generate & inserts the gong, isolates and buffers incoming speech and music and provides mixed output for monitoring.

The distribution system is divided into six zones, some of which are subdivided. For example the platforms 3 to 13 are on one zone, but each pair of platforms is a sub-zone. The announcer can only control by zone, but the sub zones are fed from the rack separately so that a failure affects only a limited part of the system. In addition the levels can be pre set separately for each of the sub-zones as circumstances demand. For each sub-zone there is a sender card which accepts the signal from the announcer position and provides routing of music, sample command and speech to Receiver/Amplifier cards adjacent to the loudspeakers.

The Receiver/Amplifier card is housed under or next to the loudspeaker or loudspeakers which it serves. It mixes incoming music and speech - the latter via the step attenuator controlled by the noise sampling circuit. A power amplifier provides signal amplification for the associated loudspeaker or loudspeakers.

A facility is provided to enable auto announce equipment to be connected to the system.

There is an auxilliary announcer unit in the Station Managers office which performs a similar function to the announcer panel, but with reduced facilities. The music cassette player is also housed here and plugged into the unit.

A further concern in the design process was the proximity of the 25,000 volt overhead cables, since this is an electric station. To avoid any induced currents in the audio and music circuits, screened cable carrying balanced floating signals was used.

A few compromises in the heights of loudspeakers had to be made - for example, in roadway areas to allow vehicles to pass under them, but now commissioned, the system appears to give the coverage for which it was designed. The system functions well, but there is always need to progress such designs further. We are currently investigating improvements in loudspeakers and in particular a double sided column loudspeaker with beam angling created by relative delays in the drivers. This would result in a neater, and easier to mount, vertical loudspeaker and would reduce the number of loudspeakers required.