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SPEAKERS FOR SOUND CANCELLATION

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INTRODUCTION

The requirements for speaker systems for sound cancellation work are largely different to those required for Hi Fi applications. These are: the largest possible amount of continuous low frequency sound emanating from as small a hole as possible in as small a box as possible. To help in achieving this, various arrangements of speakers and boxes can be used, all of which have advantages and disadvantages.

Speaker Enclosure Types - Discussion

The types of speaker enclosure available are as follows: speaker driver alone; large open baffle; closed box; vented box simple and modified; simple band-pass enclosure; two kinds of ported band-pass enclosure; three ported band-pass enclosures; the tube loaded loudspeakers; the labyrinth enclosure; and finally the general horn loaded speaker system. The first two offer nothing to the cancellation engineer and are not discussed here.

Closed Box

Even though it has been used in some installations, the closed box system has little to offer to the cancellation engineer. There are no enclosure resonances (apart from the speaker mass on the combined stiffness, of course) to enhance the driver output - which therefore has to do all the work. Cone excursion is a maximum at the 3dB low frequency point (but stays at this level down to DC). This means that long throw drive units with less copper in the magnet gap, and consequently less driving force and sensitivity, need to be used. However, the impedance seen at the terminals reaches a peak at the low frequency end of the band, which means that provided the excursion limit is not reached, then more than the 'rated' power may be fed into the system at the impedance maximum because only the DC resistance heats up the voice coil. The cone amplitude and pressure response are shown in Fig.1.

Reflex Box

Reflex Unmodified. This has more to offer the sound cancellation engineer. The cone excursion and impedance are at a minimum at the low frequency 3dB point. This means that long throw drive units are not required in general and units with a greater force capability and sensitivity can be used. However, only the rated power may be used at the 3dB point. The system has the disadvantage that the sound comes from two dissimilar sources - the driver which is relatively large and has a response extended to high frequencies - and the port which has a narrow band-pass characteristic from a relatively small opening. However, power handling can be improved over the closed box case if there is any cooling effect due to the air passing in and out of the port. The curves for this box are shown in Fig.2.

Reflex Modified. A suitable chamber with a hole in it can be placed over the drive unit. Provided the chamber and port dimensions are correctly chosen, they merely reduce the effective size of the driver while leaving its response largely unaffected at low frequencies. This allows the cancelling

source to be placed closer to the noise source - so achieving greater cancellation over a wider frequency band.

Simple Band-pass. A Helmholtz resonator is placed over the driver of a closed box system, as shown in Fig.1. The resulting response is a band-pass characteristic which may be altered by changing the relative tunings of the Helmholtz and speaker-plus-rear-cavity, as well as by changing the size of the front cavity. It is sometimes possible to achieve greater sensitivities over narrow passbands than with the reflex box alone, and the system has the advantage that all the sound emanates from a relatively small opening. There are impedance peaks at the 3dB points allowing the engineer to feed in larger amounts of power (excursion allowing) there - and in particular at the low frequency end where the noise harmonics with the greatest amplitudes are usually found. The cone amplitude characteristic is similar to the closed box case, except that there is a dip at the frequency of the Helmholtz tuning. This enclosure has found the greatest use in active noise cancellation work so far.

Two Port Band-pass Case. In this (Fig.4) case, we place the Helmholtz resonator over the driver of a bass reflex system. If the two port tunings are sufficiently far apart, then the port contributions will add in phase where they overlap and give a worthwhile improvement in the sound output in the passband, thus phase matching is a critical feature of this design. The amplitude characteristic has two dips corresponding to the two Helmholtz tunings, and because the lower resonance is not at the 3dB point the impedance characteristic still shows a useful rise at the 3dB points allowing more power to be fed in there. This system combined many of the advantages of other systems currently in use.

Other Band-pass System . There are two other configurations, namely, (1) the Helmholtz over both driver and port; (2) as (1) but with a separate port to the rear as well, as shown in Figs. 5 and 6. These systems, on balance, offer few advantages over the two other band-pass cases and in general require larger boxes.

Tube Loaded Systems (i) and (ii). In this case the speaker is located either (i) at the end of a long tube with a suitable rear enclosure, or (ii) ½ of the way down it - Fig.7. If the tube length, diameter and driver parameters are chosen correctly, the response consists of a series of resonances which can be arranged to fall exactly on the harmonics of the engine repetition rate. For a given volume of pipe, the amplitude of these resonances may be higher than with other types of enclosure having the same overall volume, and the amplitude of speaker movement is at a minimum at these peaks. However, the impedance is also at a minimum and so high power handling low excursion speakers are required for this type of enclosure - which is really only suitable for fixed speed motor systems, since it is so highly tuned.
The labyrinth speaker, which has a half wavelength pipe at the rear of the driver, is a special case of the tube loaded speaker. In this case the rear tube acts as a phase invertor for the rear cone radiation and works only at the lowest frequencies of the band because higher frequencies are removed by an absorbent stuffing. This is a less efficient way of using the same volume than most others, and so it is not used in sound cancellation work.

Other Kinds of Horn. The tube loaded speaker is really a special case of the general horn loaded system. To convert a tube to a horn, the diameter of the tube is increased progressively, according to some mathematical law, from a

narrow neck at the driver to a wide mouth. The low frequency limit is proportional to the width of the mouth and so other types of horn are totally unsuitable for cancellation work - with its requirement for as small a radiating area as possible.

Summary

The systems most suitable for noise cancellation work are the bass reflex system and two kinds of band-pass speaker enclosure. Drive units required to fall into two categories:-

(1) Large power handling, large excursion drivers with as large a force capability as the excursion requirement will allow - these are used in the simple band-pass enclosure, and

(2) large power handling, small excursion and large driving force capability drivers - these are used in the two port band-pass case and the tube loading case, where the tube is most appropriate for cancellation on fixed speed systems.

FIG.1

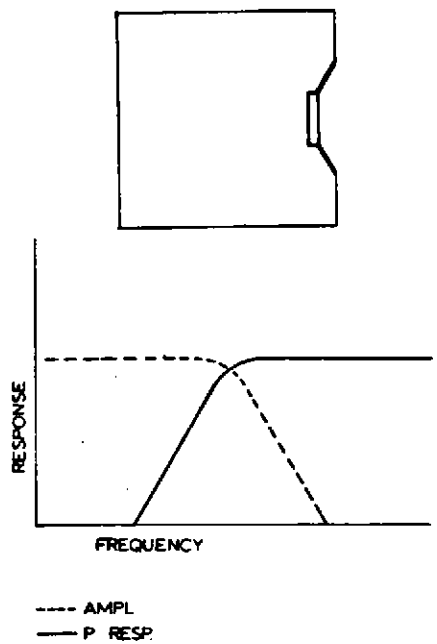

FIG.2

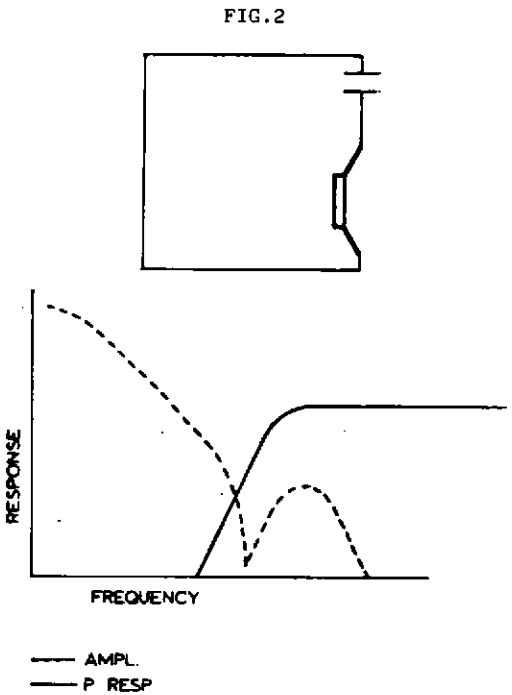

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FIG.3

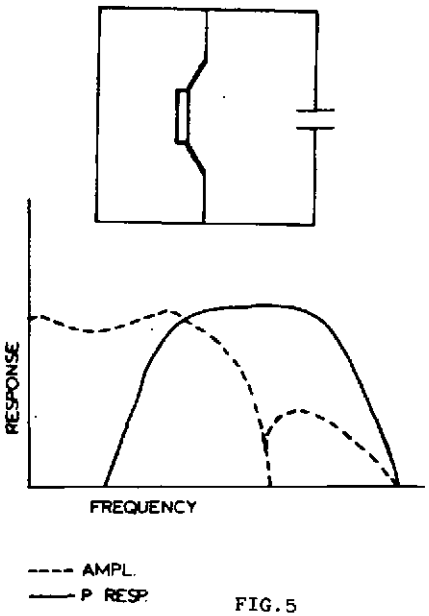

FIG.4

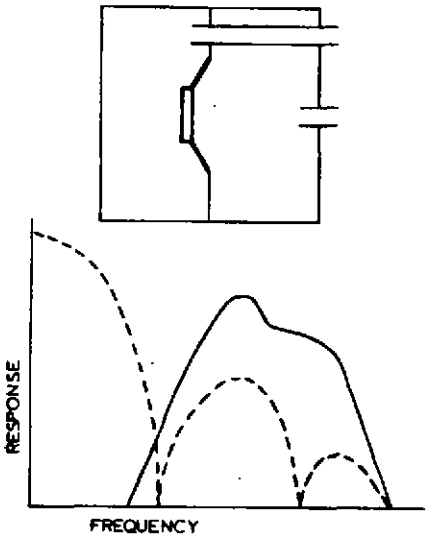

FIG.5

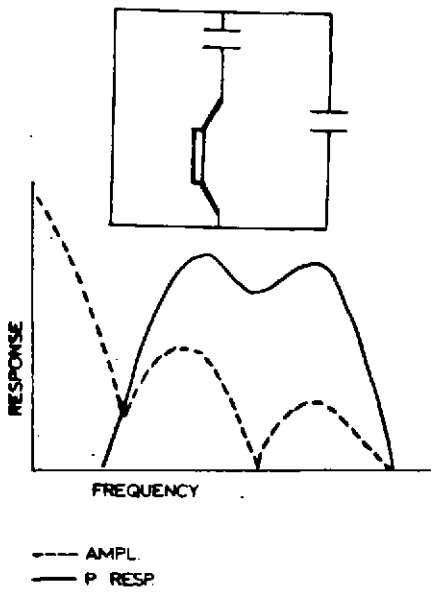

FIG.6

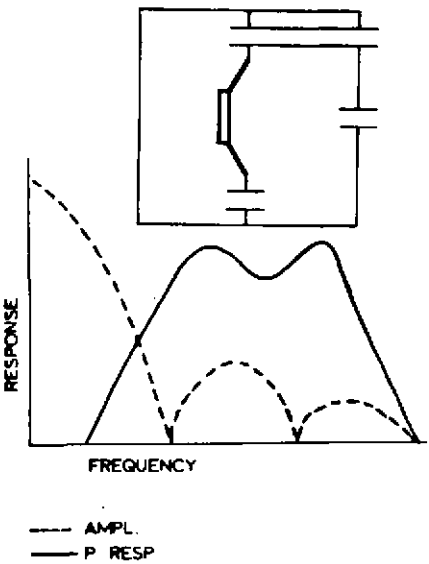

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FIG.7