

12" HIGH-QUALITY WOOFER LOUDSPEAKER



RZ 19218-1



RZ 19218-2

Though the design of this woofer is based on the normal electrodynamical principle, a number of striking features make it unique in its kind. The use of new materials and techniques allowed the development of a Hi-Fi low-note speaker which, in conjunction with high and medium-note speakers and housed in an acoustically adequate enclosure, will be found a major contribution towards natural sound reproduction. Because of its specific design and characteristics, this speaker is a solitary in our programme.

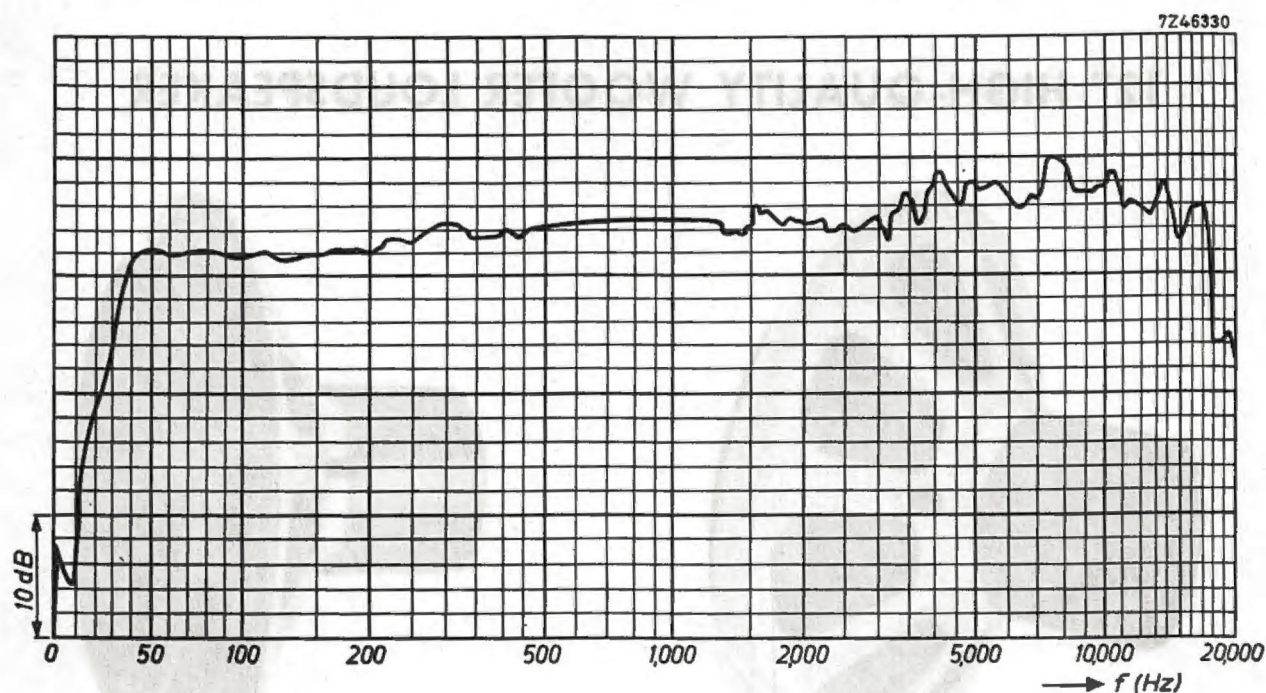
Technical performance

power handling capacity (W)	impedance at 1 kHz (Ω)	response curve	resonance frequency (Hz)	total magnetic flux (Mx)	flux density (Gs)
20	8	W	29	134 000	9 300

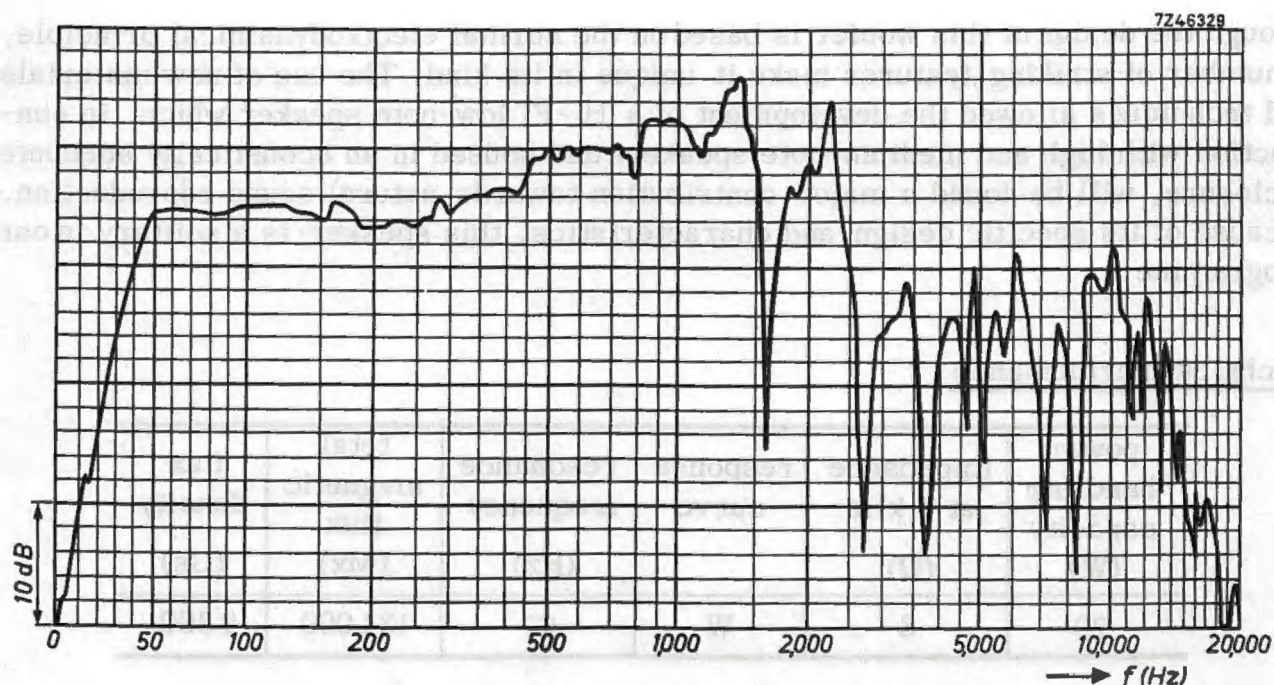
Catalog number, bulk packing : 2422 258 41121

single-unit packing : 2422 258 41161

on loudspeaker itself: 2422 258 41101

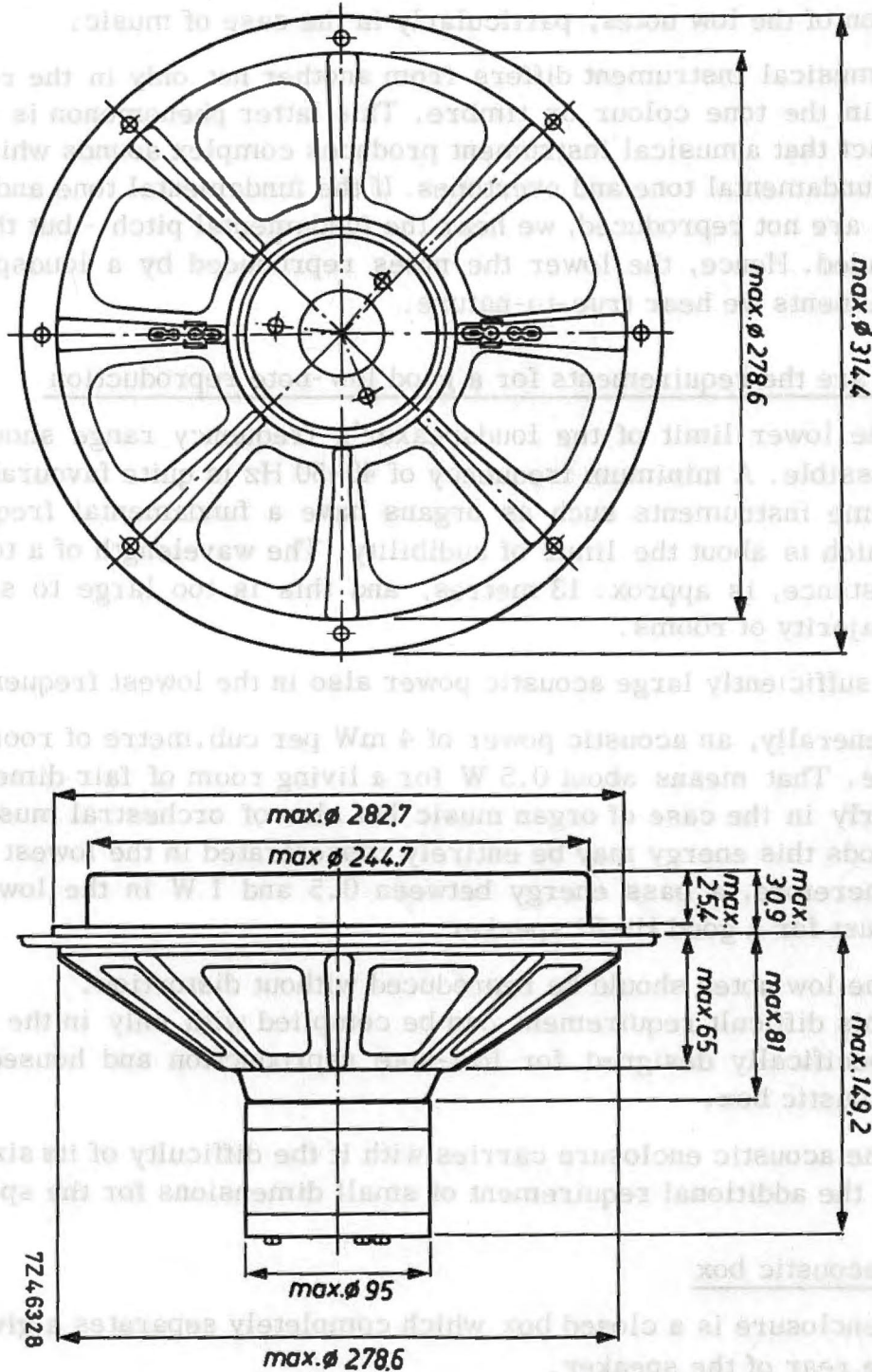


Response of the woofer in conjunction with two 5 x 7" standard speakers (M4 version) and a cross-over filter in a 45-litre acoustic box.



Response of the woofer (alone) in a 45-litre acoustic box.

Note: See also "Recommended enclosures".

Dimensions in mmWeight: 3.5 kg

REMARKS ON LOW-NOTE REPRODUCTION

Introduction

Low notes are a perpetual obstacle on the way to Hi-Fi reproduction. Prior to discussing this problem, let us consider the importance of an effective reproduction of the low notes, particularly in the case of music.

One musical instrument differs from another not only in the range of notes but also in the tone colour or timbre. This latter phenomenon is a consequence of the fact that a musical instrument produces complex sounds which are composed of a fundamental tone and overtones. If the fundamental tone and the lower overtones are not reproduced, we hear the fundamental pitch - but the timbre will be degraded. Hence, the lower the notes reproduced by a loudspeaker, the more instruments we hear true-to-nature.

What are the requirements for a good low-note reproduction

1. The lower limit of the loudspeaker's frequency range should be as low as possible. A minimum frequency of 40-50 Hz is quite favourable.
Some instruments such as organs have a fundamental frequency of 16 Hz, which is about the limit of audibility. The wavelength of a tone of 25 Hz, for instance, is approx. 13 metres, and this is too large to sound well in the majority of rooms.
2. A sufficiently large acoustic power also in the lowest frequencies.
3. Generally, an acoustic power of 4 mW per cub.metre of room volume is ample. That means about 0.5 W for a living room of fair dimensions. Particularly in the case of organ music but also of orchestral music, for short periods this energy may be entirely concentrated in the lowest octaves.
Therefore, a bass energy between 0.5 and 1 W in the lowest octaves is a must for a good Hi-Fi speaker.
4. The low notes should be reproduced without distortion.
This difficult requirement can be complied with only in the case of speakers specifically designed for low-note reproduction and housed in an adequate acoustic box.
5. The acoustic enclosure carries with it the difficulty of its size, and this leads to the additional requirement of small dimensions for the speaker system.

The acoustic box

The enclosure is a closed box which completely separates a given volume of air at the rear of the speaker.

Advantages

1. Between the so-called relaxation frequency (800-1000 Hz) and the frequency resonance, the low-note reproduction is improved by about 6 dB per octave with regard to a speaker without baffle.
The acoustic box acts, as it were, as a baffle of infinite size.
2. The separated air volume accomplishes an effective damping and, hence, an increased loadability.
3. The separated air volume increases the stiffness of the cone suspension and so prevents distortion due to non-linearity of the cone movement.

Drawbacks

1. The separated air raises the resonance frequency of the system.
2. The large box occupies much space.

With this woofer, these drawbacks are limited to the strict minimum.

The loudspeaker

The following equation applies to the acoustic power produced by a loudspeaker:

$W = k \times f^4 \times s^2 \times A^2$, where

W = the acoustic energy in watts,

f = the frequency,

s = the stroke of the moving coil,

A = the area of the cone.

This implies that the product sA should be large enough to render, also in the lowest octaves, the required quantity of acoustic power (s is two times the amplitude of the coil movement in the air gap).

For a satisfactory low-note reproduction, the self-resonance of the speaker should be as low as possible, and also the resonance increase resulting from the insertion in a box. This increase will be greater when the box volume is smaller and the cone diameter larger. Hence, to obtain the final resonance-frequency of the system as low as possible at a box volume as small as possible, the cone diameter should not be chosen too large.

In order nevertheless to have a large product sxA , a large stroke is therefore a requirement of pre-eminent importance.

For the avoidance of distortion, notwithstanding the long stroke of the coil, the following requirements should be met.

Even in its ultimate positions, the coil should remain within the homogeneous magnetic field.

The reaction of cone and centring ring should always be in accordance with the coil movements.

This means that the cone suspension should be flexible, that the cone itself should be stiff, and that the non-harmonic movements of cone and centring ring should be adequately damped. Furthermore, an efficiency as high as possible is of importance to acquire the maximum acoustic output with the minimum electric input. This requires, among other things, a powerful magnetic field, a light cone and a light centring ring. Requirements to obtain a low resonance frequency are, inter alia, a flexible cone suspension and a not too small cone mass, which involves a fairly large cone diameter.

To complete the situation, we observe that an adequate loadability requires an effective damping and, therefore, a not too large volume of separated air, a sufficiently strong cone and a sturdy suspension.

From the above, the following will be clear.

The loudspeaker should have a cone of great stiffness, a powerful magnetic field, a large coil stroke in a homogeneous field, and a low resonance frequency.

The optimum compromise should be found for the stiffness of the cone suspension, the cone diameter, the cone weight and the box volume.

After a great number of experiments, we obtained the following as the optimum result.

DESIGN OF THE WOOFER

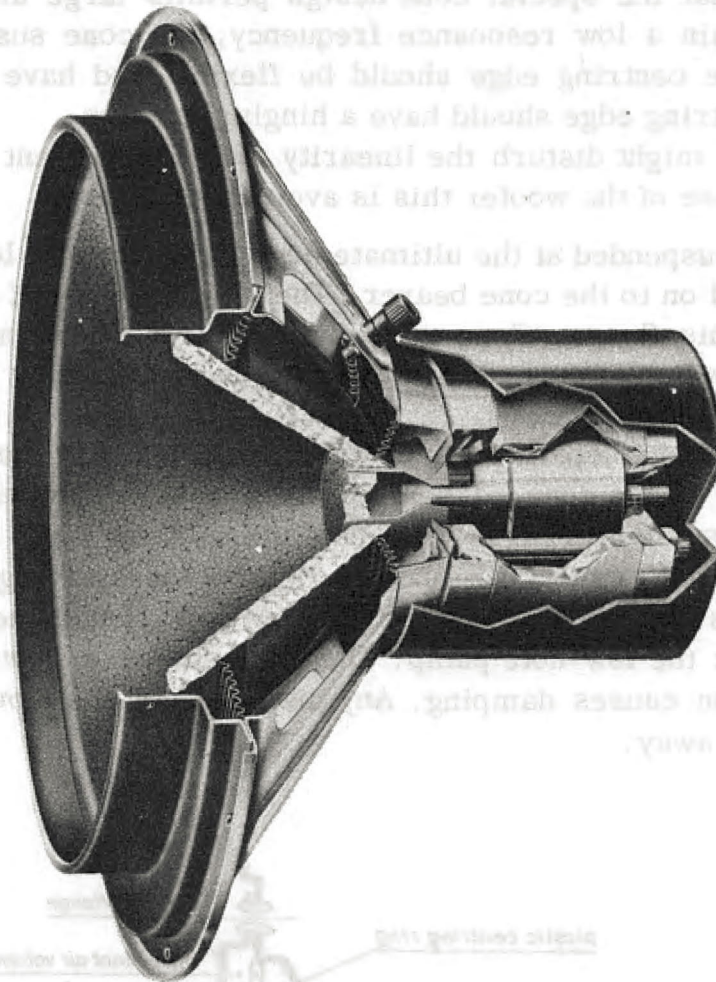
The cone

Foam plastic as the cone material guarantees a combination of great stiffness and a low mass.

Of course, though not ideal, paper is not a bad cone material; until recently, there was no second of equal strength, lightness and acoustic effect. The specific weight of cone paper is 0.2. However, the lacquer required to obtain resistance to moisture, raises the specific weight to 0.5.

The specific weight of the plastic foam used for the woofer is 0.02. That means, the thickness may be 25 times as large before the weight of a corresponding cone in paper is reached. Thus, diaphragms having a thickness of 1 cm and more can be used that are perfectly rigid. These diaphragms, including the voice coil, do not weigh more than about 12 g.

In this case, it is not necessary to stiffen the cone artificially through the box to reduce the distortion, and the dimensions of the box can be chosen purely in view of the low-note reproduction. Distortions as a result of deformations of the diaphragms are likewise out of the question.



Frequency characteristic

The almost complete stiffness of the cone engenders a drawback. Paper diaphragms vibrate as a whole as long as the wavelength of the tone produced exceeds the cone diameter. Hence, at rising frequency, the effective area of the paper cone and, correspondingly, the moving mass, decrease steadily. As a result of this phenomenon, paper cones reproduce notes beyond 1 kHz with an adequate efficiency.

In the case of a relatively small cone such as that of the woofer, however, rise in frequency causes no drop in moving mass and, consequently, beyond the frequency at which the cone ceases to act as a piston, no effective output is to be expected. Therefore, the woofer should be used exclusively in conjunction with other speakers for reproduction of the high and the medium notes.

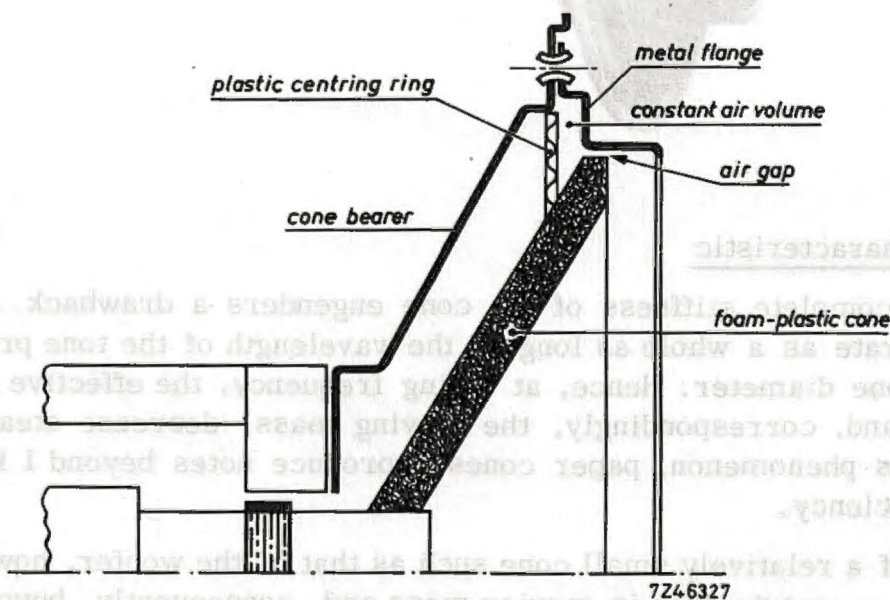
Cone suspension

It will be clear that the special cone design permits large amplitudes. Therefore, and to obtain a low resonance frequency, the cone suspension should be flexible. Also the centring edge should be flexible and have a large area; the ridges in the centring edge should have a hinging function.

The hinging edge might disturb the linearity of the movement and so cause distortion. In the case of the woofer this is avoided as follows.

The cone is not suspended at the ultimate edge but somewhat lower, and a metal flange is attached on to the cone bearer. The ultimate edge of the cone moves to and fro within this flange. Cone edge, centring ring and flange form a ring-shaped chamber which is only connected to the external air by means of a narrow gap between cone and flange.

The dimensions of the separate air chamber are such that theoretically, during the entire stroke of the cone edge, the volume of the chamber remains almost constant if we assume a linear movement of the centring ring. According as non-linearity in the cone suspension tends to deform the centring ring, any change in volume pumps the air through the narrow gap. Hence the surname of this original speaker: the low-note pump. The gap acts as a flow resistance whose energy absorption causes damping. Any distortion of the moving system is, as it were, pumped away.



The permissible stroke of the cone

All causes of distortion resulting from diaphragm deformations now being eliminated, or at least substantially reduced, it is all the more important to avoid any distortion resulting from non-linearity in the diaphragm drive as well.

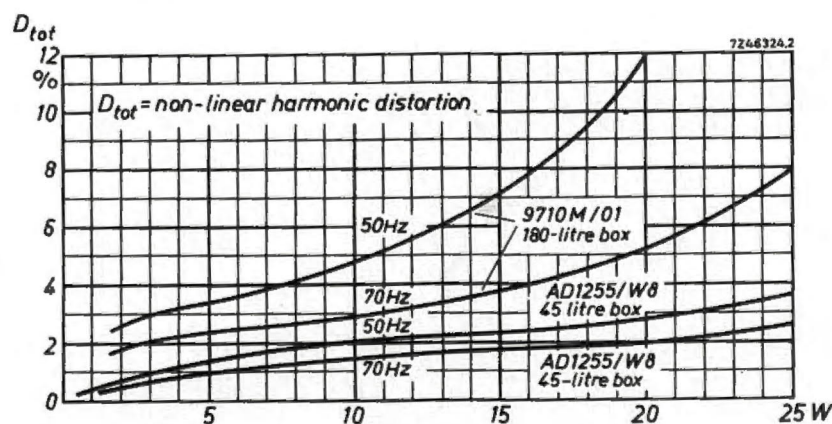
The force exerted on the voice coil is $0.1 \times B \times I \times L$, where B , is the induction, I the current through the coil and L the length of wire. At any moment and independent of the position of the coil, this force should be proportional to I and, therefore, the coil should be always in a field of constant intensity.

In principle, there are two manners to meet this condition. The first one is making the coil considerably longer than the thickness of the pole plate or, in other words, the height of the field in the air gap. An advantage of this method is a high field-intensity without a heavy magnet, which tends to keep the price low.

A disadvantage is a significant increase in mass and resistance of the coil, resulting in a drop in efficiency. Therefore, a more powerful amplifier will be required and the price of the total equipment will rise. Of even greater consequence may be the fact that the inactive part of the coil increases the internal resistance of the amplifier and so adversely affects the damping factor.

An alternative is heightening the air gap so as to keep the coil movement within the homogeneous field. In this case, the mass and the resistance of the coil can be kept as small as possible - but a drawback is, of course, the necessity of a much larger magnet. Freedom of distortion cannot be obtained on the cheap.

It is the second method that was applied to the woofer. The thickness of the pole plate is two times the length of the coil which can, thus, make a stroke of 8 mm within the homogeneous part of the field. This stroke is an enormous feature of this speaker, the more so as - even at the stroke of this length - no distortion whatever of the signal occurs.



Non-linear distortion as a function of the input power compared with that of an $8\frac{1}{2}$ ", 10 W high-quality loudspeaker.

The acoustic box

Building the speaker into an enclosure of about 40 litres nett, makes the resonance frequency of 29 Hz rise to about 50 Hz.

Measurements in a box of this volume demonstrated that even a 50-W load did not cause any audible distortion; in larger boxes, an energy of at least 20 W is permissible (these figures apply to normal orchestral music). In the case of musical passages such as low organ notes, where almost the entire reproduction occurs in the lowest frequencies, a smaller electric energy suffices for an adequate sound intensity.

To obtain the optimum reproduction quality, we advice to build the speaker in an enclosure of 40-50 litres nett, which results in an almost flat response curve between 40 and 1000 Hz. At a load of 30 W, the distortion is max. 3 % at half an octave beyond the resonance frequency.

Reproduction of the high and medium notes

If the speakers for these notes are housed in the same enclosure - of course in a separate room - it is not necessary to choose the cross-over frequency extra low: this would cause difficulties as regards the filter dimensions. A cross-over frequency of 800 Hz and a cut-off rate of 12 dB per octave are recommended.

