FINK team

# WM-4

FinkTeam's WM-4 is a three-way, twin-cabinet design featuring a 15-inch bass driver, twin 5.5-inch flat-diaphragm midrange drivers and an AMT tweeter.

The two midrange drivers and tweeter, arranged as an MTM (D'Appolito) array, are housed in the top cabinet which is faceted to reduce diffraction effects.

The bass driver occupies the lower cabinet and is reflex loaded via a large forward-firing port.

The WM-4 combines wide bandwidth (30 Hz-30 kHz) with high sensitivity (90 dB) but is easy to drive, with an average impedance of around 6 ohms and low impedance phase angles.

To make the WM-4 better adapted to use with some valve amplifiers, an optional impedance smoother is provided which reduces the impedance variation and hence the frequency response errors that result from high amplifier output impedance.

The WM-4 is a loudspeaker with two great abilities: it is capable of revealing the smallest change in the partnering system and thus is a wonderful analytical tool. However, and very unusually for an analytical tool it is capable of kicking back and playing music of any era and making it enjoyable, involving and communicative.

The two abilities are rarely found together in loudspeakers designs but the wide dynamic range and very low distortion of the WM-4 deliver performance at the highest level.

# Cabinet

Typical loudspeaker cabinets have pronounced structural resonances which are very audible and reduce the speaker's 'signal-to-noise ratio'. At FinkTeam we take this aspect of loudspeaker performance very seriously because we know that a quiet cabinet allows the reproduction of low-level detail in a recording which is otherwise swamped by spurious cabinet output. Coloration and time smear are reduced, stereo image focus is improved, and listener fatigue avoided.

The lower and upper cabinets of WM-4 are designed differently according to the frequency range of the vibrations to which they are subjected by their respective drive units. Compliant spacers position the upper cabinet precisely on the lower one while ensuring effective vibration isolation between the two.

With the bass cabinet the design emphasis is on making the cabinet as stiff as possible, to force panel resonances above the crossover frequency to the midrange drivers. This is achieved using internal bracing, the positioning of which was optimised using finite element analysis and confirmed with laser interferometry measurements. It is important that braces add stiffness only where needed, otherwise they can transfer energy to other parts of the cabinet, making the control of cabinet vibration harder.

With the midrange/tweeter cabinet the design emphasis is on panel damping. It is impossible to force all the panel bending resonances above the passband so instead they are damped to reduce their amplitude to below audibility. This is achieved using a multilayer construction that combines multi-thickness MDF panels with a damping layer whose internal friction converts vibration into heat. FinkTeam-developed algorithms help specify ideal material thicknesses to achieve the best results, but the ultimate determination is made by subjective assessment.

Structural resonances are not the only ones we need to control: there are also standing waves within the enclosed volume of air. These impose forces on the enclosure walls and can also escape the cabinet either by passing through the diaphragm of the drive unit or, in the case of a vented speaker like the WM-4, through the reflex port.

The traditional solution is to fill the space with a fibrous tangle such as long-hair wool or BAF, or a flexible or rigid open-cell foam material. These subject internal air movement to frictional losses which damp the resonances. But they apply these losses at all frequencies, not just the resonance frequencies, and this can have a negative effect on sound quality. Dynamics and precision both suffer.

We've used a very different solution in the WM-4. Tuned quarter-wave resonators, mounted within the cabinet, act to equalise the pressure differential between the extremities and centre of the air space which occurs at the fundamental internal resonance. This virtually removes the resonance without the need for large amounts of cabinet stuffing.

„ Truly delicate one minute
punching like a
prizefighter the next –
the WM-4 is truly captivating. “

Karl-Heinz Fink

# Woofer

Fifteen-inch woofers have a long history. Before the days of transistor amplifiers, the limited electrical output power of tube amplifiers made it necessary to use drive units with high efficiency. The easiest way of increasing a driver's efficiency is to increase its radiating area, and the 15-inch driver proved to be a good compromise between size and efficiency. At the same time 15-inch woofers became a de facto standard for pro audio applications, whether in sound reinforcement systems or bass guitar amplifiers.

When transistor amplifiers eroded the need for large drivers, the 15-inch hi-fi-woofer fell out of fashion. It survived in the pro audio arena where 15-inch drivers still play an important role in numerous applications, but the requirements for this type of driver are somewhat different to those in the hi-fi-world. A typical pro audio 15-inch woofer provides high power handling, high excursion and is compatible with quite a small cabinet. It is optimised to run most of the time at 20 to 50 per cent of its rated power handling. On the hi-fi side, design priorities would be low distortion and low mechanical losses while cabinet size is not as restricted.

Having screened the market for possible candidates for the WM-4 it became apparent to us that none of the 15-inch pro audio woofers is suitable for a home hi-fi application, so a new 15-inch woofer had to be developed from scratch. The woofer we designed features a stiff corrugated straight sided cone made from glassfibre-reinforced non-pressed paper pulp with a thickness of 3 mm to prevent sound leaking through it from inside the cabinet. The cone is rather deep to make it as stiff as possible, with the result that the first cone breakup mode occurs at a high 1 kHz, well outside the woofer's operating range.

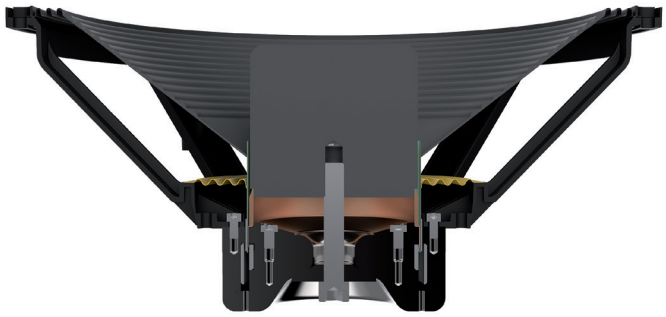
Hi-fi woofers generally use half-roll rubber surrounds but the WM-4's is a triple-roll fabric type which, with the paper cone, gives it the appearance of a pro woofer. The difference is that we have co optimised the stiffness of the surround and spider (suspension) to achieve the linearity of a half-roll surround but without its high hysteresis. Subjectively this ensures 'quick', 'snappy' bass.

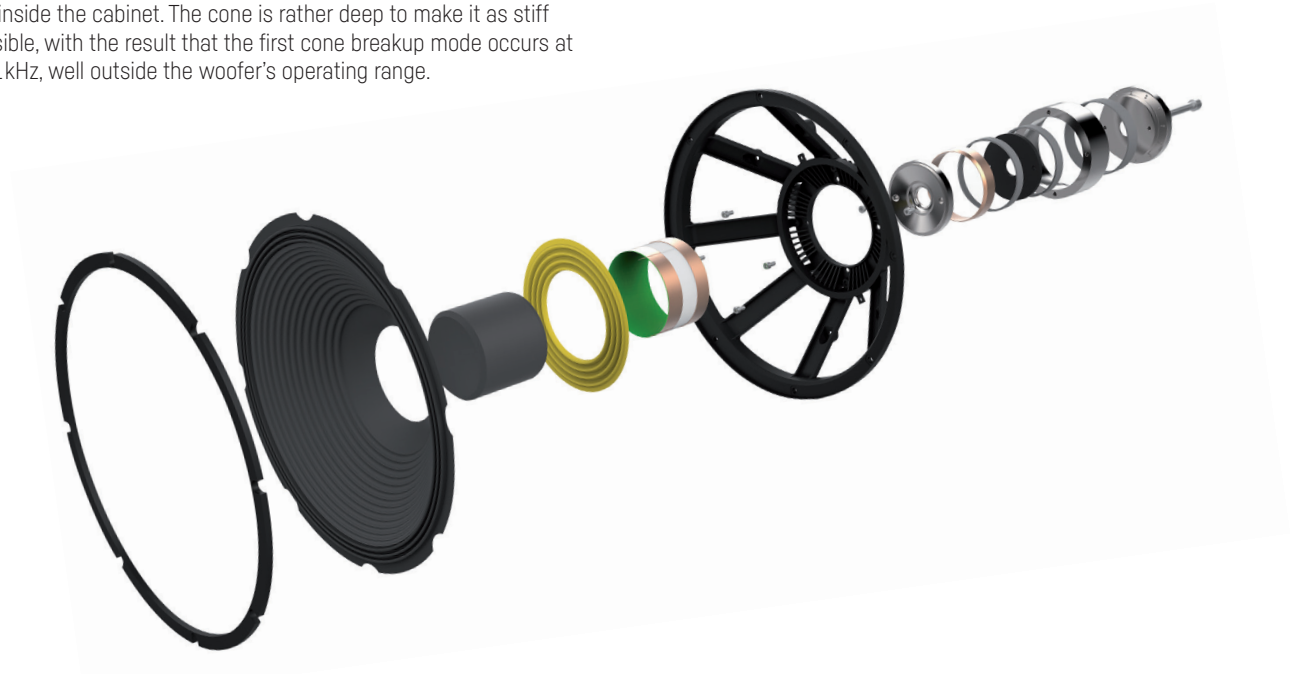
The motor uses a neodymium magnet within the 102 mm diameter voice coil. Its excursion capability was determined by the requirements of normal listening levels. It was modelled on the premise of loud hi-fi use rather than for use as a PA system. Thus, the voice coil's winding height is 20 mm, combined with a 10 mm magnet gap height. Within the motor system multiple aluminium demodulation rings compensate for voice-coil induced eddy currents, while a copper shield on the pole piece reduces voice coil inductance. Together these measures assure extraordinary low distortion figures across the whole woofer passband, and low inductance change with excursion.

A corrugated straight-sided cone, supplied by Dr Kurt Mueller in the UK is used made from glassfibre-reinforced non-pressed paper pulp. The cone thickness is 3 mm to help prevent sound migrating from inside the cabinet.

The spider and surround geometries have been optimised to match the force versus excursion (Bl(x)) characteristic of the motor. Spider and surround have nearly identical compliance values, so the woofer in effect features a double suspension system which prevents instability and cone rocking at high excursions. The spider is made from pure Nomex fabric which guarantees low mechanical losses and minimal degradation due to ageing.

Unlike a typical single-roll foam or rubber surround, the triple-roll poly cotton surround generates a stiffness versus excursion (Kms(x)) characteristic comparable to that of the spider.





# Midrange

## We had three principal objectives in designing the midrange driver: wide bandwidth, freedom from ‘cavity effect’ and low distortion.

We’ve achieved this by using our made in house FMWD (Flat Membrane Wide Dispersion) units, optimised for high-performance applications, designed by and exclusive to FinkTeam. These operate pistonically on-axis but exploit bending resonances at 2, 6, 12 and 18 kHz to bolster off-axis output. These resonances are controlled by two damping pads mounted either side of the flat diaphragm to ensure a wide, flat on axis frequency response and smoothly decaying power response.
The wide bandwidth allows optimum choice of crossover frequencies and simplifies crossover design. Because the diaphragm is planar, the driver does not cause the diffraction effects that result when grazing radiation (sound travelling close to the baffle surface) encounters the cavity formed by a conventional cone diaphragm. This removes a distinctive colouration.

The third objective was achieved in significant part by minimizing back EMF induced currents in the motor system. Two aluminium tubes below and above the magnet gap and a copper shield on the inner pole piece keep third harmonic distortion low, which is otherwise generated by eddy currents travelling in the motor’s metal structure. The suspension system has been designed to generate symmetric reaction forces in the operating range and to match the motor’s force versus displacement (Bl(x)) characteristic.

5 mm thick paper honeycomb panel for minimum mass and carefully dimensioned bending stiffness.

The motor system features a neodymium magnet located inside the voice coil. Two aluminium demodulation rings inside and outside the magnet gap minimise inductance variations with cone excursion, while a copper cap on the inner pole piece reduces overall inductance. Both measures assure low distortion.

75 mm diameter copper clad aluminium wire (CCAW) voice coil wound on a GRP (glassfibre) former.

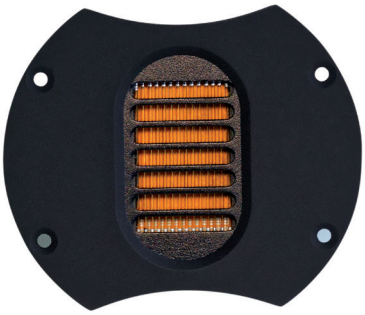
# HF Unit

## The tweeter is an Air Motion Transformer (AMT) operating according to the principles established by its inventor Oskar Heil.

Developed by Mundorf together with FinkTeam and manufactured specifically for FinkTeam by Mundorf, the AMT has a strong, 25 µm-thick pleated Kapton diaphragm with 50 µm aluminium strips.

This material has extremely good internal damping, resulting in particularly low distortion. A special etching process was developed to produce it and the diaphragm configuration optimized through a large number of tests.

Since the diaphragm dimensions are comparable to those of a 25 mm dome tweeter, dispersion is also similar. Frequency response reaches up to 30 kHz while distortion is very low and mainly second harmonic. The AMT’s almost constant impedance also facilitates simplified crossover design.



# Specifications

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| Finishes | The WM-4 is available to order with the colour and veneers chosen by the prospective owner |
| Frequency response | 30 Hz – 30 kHz, – 6 dB |
| Average impedance | 6.5 ohms (6.2 ohms with optional impedance smoother) |
| Minimum impedance | 4.1 ohms |
| Sensitivity | 90 dB SPL at 1m for 2.83Vrms input |
| Distortion | <0.2 % THD at 90 dB SPL |
| Bass Unit: | Bespoke 15-inch, designed and manufactured by FinkTeam |
| Twin Midrange | 5.5-inch FMWD, designed by manufactured by FinkTeam |
| HF Unit | 1260 mm² AMT (Mundorf) |
| Terminals | Mundorf silver-plated pure copper |
| Dimensions | 1420 × 450 × 580 mm (HWD) |
| Weight | 135 kg each |

Choice of standard finishes or any finish to special order.



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